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SUSTAINABLE AGRICULTURE AND FOOD

VOLUME I

HISTORY OF AGRICULTURE AND FOOD

EDITED BY

JULES PRETTY

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Sustainable Agriculture and Food

Volume I

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Edited by

Jules Pretty

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List of Acronyms and Abbreviations

AARD	Agency for Agricultural Research and Development
AFTPs	Agroforestry Tree Products
ARPAC	Agricultural Reseach Policy Advisory Committee
BTZ	Biotechnology Trust of Zimbabwe
CAAS	Chinese Academy of Agricultural Sciences
CAS	Chinese Academy of Sciences
CBD	Convention on Biological Diversity
CENFOR	Center for Forestry Research (Amazon)
CGIAR	Consultative Group on International Agricultural Research
CHAGS	Conference on Hunting and Gathering Societies
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	Centro Internacional de Mejoramento de Maíz y Trigo
CIP	Centro Internacional de Papas
CODESU	Consorcio para el Desarrollo Sostenible de Ucayali
CPR	common property regime
CRIFC	Central Research Institute for Food and Crops
CSP	Conservation Security Program
EA	Environment Agency (UK)
EDRSS	Ecological Demonstrative Rebuilding for Sustainable Settlements
ESSO	Standard Oil of New Jersey
FAO	Food and Agriculture Organization (UN)
GDP	gross domestic product
GIS	geographic information system
IBP	International Biological Program
IBPGR	International Board for Plant Genetic Resources
ICA	Instituto Columbiano Agropecuário
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IFS	integrated farming system
IIAP	Instituto de Investigación de la Amazonía Peruana
IITA	International Institute of Tropical Agriculture
INAC	Indian and Northern Affairs Canada
INIA	Instituto Nacional de Investigación Agraria
INIFAP	Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias

INRM	integrated natural resource management
IPCC	Intergovernmental Panel on Climate Change
IPM	integrated pest management
IRAD	Institut de Recherche Agricole pour le Développement
IRRI	International Rice Research Institute
IUCN	International Union for the Conservation of Nature and Natural Resources
LMO	living modified organism
MEA	Millennium Ecosystem Assessment
NBC	national biosafety committee
NBF	national biosafety framework
NEP	New Economic Policy (Russia)
NGO	non-governmental organization
PCARRD	Philippine Council for Agriculture, Forestry, and Natural Resources Research
PFI	Practical Farmers of Iowa
PFTs	plant functional types
RDAs	recommended daily allowances
SADC	Southern African Development Community
SARD	Sustainable Agriculture and Rural Development
SRI	system of rice intensification
TAC	Technical Advisory Committee
TEK	traditional ecological knowledge
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	US Aid Agency
USDA	US Department of Agriculture
VIR	N. I. Vavilov All-Union Institute of Plant Industry
WCED	World Commission on Environment and Development
WN	World Neighbors
WTO	World Trade Organization

Overview to Four Volumes: Sustainable Agriculture and Food

Jules Pretty

The Context for Agricultural Sustainability

The interest in the sustainability of agricultural and food systems can be traced to environmental concerns that began to appear in the 1950s and 1960s. However, ideas about sustainability date back at least to the oldest surviving writings from China, Greece and Rome (King, 1911; Cato, 1979; Hesiod, 1988; Conway, 1997; Li Wenhua, 2001; Pretty, 2002). More recent concerns began to develop during the 1960s, and were particularly driven by Rachel Carson's book *Silent Spring* (Carson, 1963). Like other popular and scientific studies at the time, it focused on the environmental harm caused by agriculture. In the 1970s, the Club of Rome identified the economic problems that societies would face when environmental resources were overused, depleted or harmed, and pointed towards the need for different types of policies to generate sustainable economic growth.

In the late 1980s, the World Commission on Environment and Development (WCED), chaired by Gro Harlem Brundtland, published *Our Common Future*, the first serious attempt to link poverty alleviation to natural resource management and the state of the environment. Sustainable development was defined as 'meeting the needs of the present without compromising the ability of future generations to meet their own needs'. The concept implied both limits to growth and the idea of different patterns of growth (WCED, 1987).

In 1992, the UN Conference on Environment and Development was held in Rio de Janeiro. The main outcome was Agenda 21, a 41-chapter document setting out priorities and practices across all economic and social sectors, and how these should relate to the environment. Chapter 14 addressed Sustainable Agriculture and Rural Development (SARD). The principles of sustainable forms of agriculture that encouraged minimizing harm to the environment and human health were agreed. However, progress since then has not been good, as Agenda 21 was not a binding treaty on national governments, and all remain free to choose whether to adopt or ignore these principles (Pretty and Koohafkan, 2002). The

'Rio Summit' was, however, followed by several important actions that came to affect agriculture, including the signing of the Convention on Biodiversity in 1995; the establishment of the UN Global Integrated Pest Management (IPM) Facility in 1995, which provides international guidance and technical assistance for integrated pest management; the signing of the Stockholm Convention on Persistent Organic Pollutants in 2001, so addressing some problematic pesticides; and, ten years after Rio, the World Summit on Sustainable Development held in Johannesburg. In 2005, the Millennium Ecosystem Assessment then drew attention to the value of environmental services, and in particular the role that agriculture plays in affecting them (MEA, 2005).

Today, concerns about sustainability centre on the need to incorporate agricultural technologies and practices that (i) do not have adverse effects on the environment (partly because the environment is an important asset for farming); and (ii) are accessible to and effective for farmers, and lead both to improvements in food productivity and have positive side-effects on environmental goods and services. Sustainability in agricultural systems incorporates concepts of both resilience (the capacity of systems to buffer shocks and stresses) and persistence (the capacity of systems to continue over long periods), and addresses many wider ecological, economic and social and political dimensions:

- *Ecological* – the core concerns are to reduce negative environmental and health externalities, to enhance and use local ecosystem resources, and preserve biodiversity. More recent concerns include broader recognition of the positive environmental services from agriculture (including carbon capture in soils, flood protection, biodiversity services).
- *Economic* – economic perspectives seek to assign value to ecological assets, and also to include a longer time frame in economic analysis. They also highlight the often hidden subsidies that promote the depletion of resources or unfair competition with other production systems.
- *Social and political* – there are many concerns about the equity of technological change. At the local level, agricultural sustainability is associated with farmer participation, group action and the promotion of local institutions, culture and farming communities. At the higher level, the concern is for enabling policies that target poverty reduction in developing countries and diet management in industrialized countries.

In recent decades, there has been remarkable growth in agricultural production worldwide. Since the beginning of the 1960s, aggregate world food production grew by 145 per cent to the early part of the 21st century. In Africa, it increased by 140 per cent, in Latin America by almost 200 per cent and in Asia by 280 per cent. The greatest increases have been in China, where a five-fold increase occurred, mostly during the 1980s and 1990s. In industrialized countries, production started from a higher base; yet it still doubled in the US over 40 years, and grew by 68 per cent in western Europe (FAO, 2005).

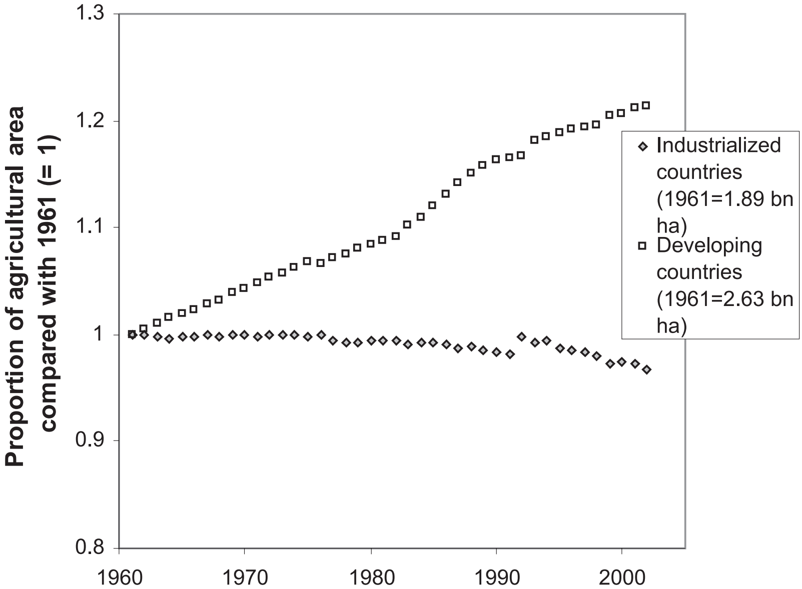
Over the same period, world population grew from 3 to 6.5 billion. Again, though, per capita agricultural production has outpaced population growth. For each person today, there is 25 per cent more food compared with 1960. These aggregate figures, however, hide important regional differences. In Asia and Latin America, per capita food production increased by 76 per cent and 28 per cent respectively. Africa has fared badly, with food production per person 10 per cent lower in the early 2000s than in 1960. China, again, performed best, with a trebling of per capita food production over the same period. These agricultural production gains have lifted millions out of poverty and provided a platform for both rural and urban economic growth in many parts of the world.

However, these advances in aggregate productivity have not brought reductions in the incidence of hunger for all. In the early 21st century, there were still more than 800 million people hungry and lacking adequate access to food. A third were in East and South-East Asia, another third in South Asia, a quarter in sub-Saharan Africa, and 5 per cent each in Latin America/Caribbean and in North Africa/Near East. Nonetheless, there has been progress, as the incidence of undernourishment stood at 960 million in 1970, comprising a third of all people in developing countries at the time.

Despite this progress in food output, it is likely that food-related ill health will remain widespread for many people. As world population continues to increase, until at least the mid 21st century, so the absolute demand for food will also increase. Increasing incomes will also mean people will have more purchasing power, and this will increase demand for food. But as diets change, so demand for the types of food will also shift radically, with large numbers of people going through the nutrition transition. In particular, increasing urbanization means people are more likely to adopt new diets, particularly consuming more meat, fats and refined cereals, and fewer traditional cereals, vegetables and fruit (Popkin, 1998).

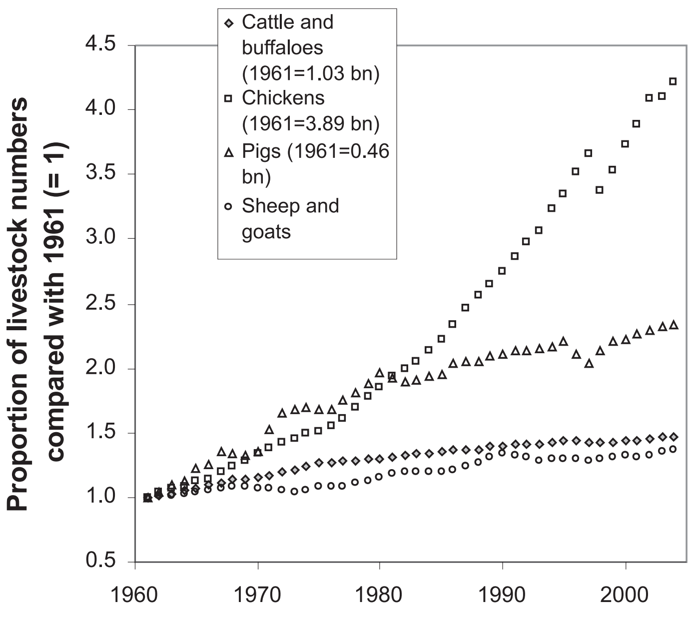
At the same time as these recent changes in agricultural productivity, consumer behaviour over food and the political economy of farming and food (Goodman and Watts, 1997), agricultural systems are now recognized to be a significant source of environmental harm (Tilman, 1999; Pretty et al, 2000; MEA, 2005; Pretty, 2007). Since the early 1960s, the total agricultural area has expanded by 11 per cent from 4.5 to 5 billion hectares, and arable area from 1.27 to 1.4 billion hectares. In industrialized countries, agricultural area has fallen by 3 per cent, but has risen by 21 per cent in developing countries (Figure 1a). Livestock production has also increased, with a worldwide four-fold increase in numbers of chickens, a two-fold increase in pigs, and 40–50 per cent increases in numbers of cattle, sheep and goats (Figure 1b).

During this period, the intensity of production on agricultural lands has also risen substantially. The area under irrigation and number of agricultural machines has grown by about two-fold, and the consumption of all fertilizers by four-fold (and nitrogen fertilizers by seven-fold) (Figures 1c and 1d). The use of pesticides in agriculture has also increased dramatically, and now amounts to some 2.56



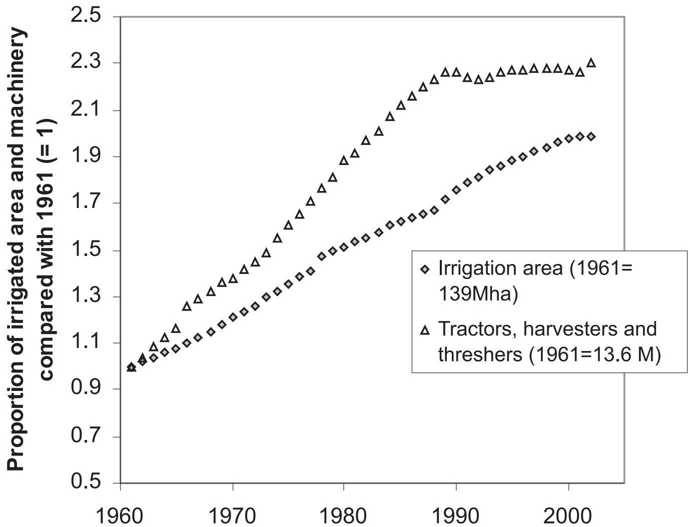
Source: FAO (2005)

Figure 1a *Agricultural area (1961–2002)*



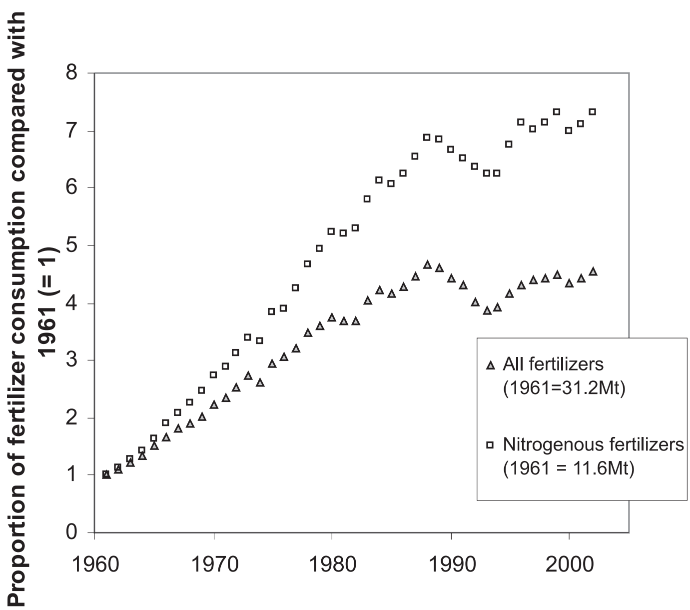
Source: FAO (2005)

Figure 1b *Head of livestock, world (1961–2004)*



Source: FAO (2005)

Figure 1c *Irrigated area and agricultural machinery, world (1961–2002)*



Source: FAO (2005)

Figure 1d *World fertilizer consumption (1961–2002)*

Table 1 *World and US use of pesticide active ingredients (mean for 1998–1999)*

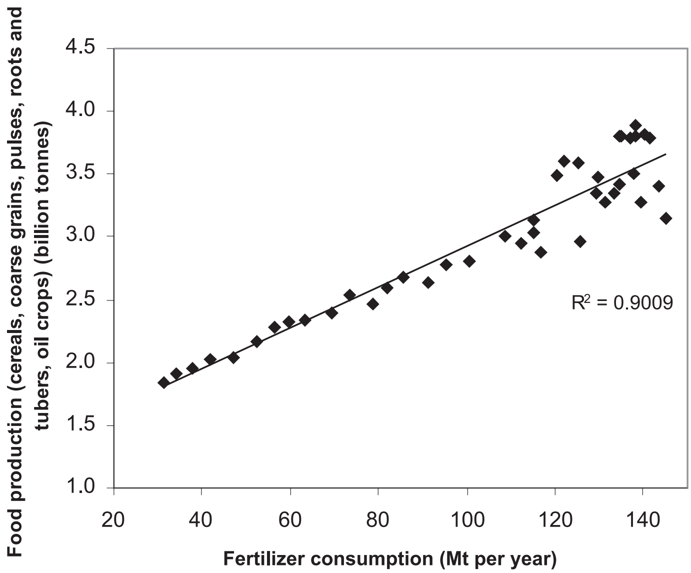
Pesticide use	*World pesticide use*		*US pesticide use*	
	(Million kg ai[1])	*%*	*(Million of ai[1])*	*%*
Herbicides	948	37	246	44
Insecticides	643	25	52	9
Fungicides	251	10	37	7
Other[2]	721	28	219[3]	40
Total	2563	100	554	100

1 ai = active ingredient.
2 Other includes nematicides, fumigants, rodenticides, molluscicides, aquatic and fish/bird pesticides and other chemicals used as pesticides (e.g. sulphur, petroleum products).
3 Other in the US includes 150 million kg of sulphur, petroleum used as pesticides.
Source: Pretty and Hine (2005), using EPA (2001), OECD (2001)

billion kilogrammes (kg) per year. In the early 21st century, the annual value of the global market was US$25 billion, of which some $3 billion of sales was in developing countries (Pretty, 2005). Herbicides account for 49 per cent of use, insecticides 25 per cent, fungicides 22 per cent, and others about 3 per cent (Table 1). A third of the world market by value is in the US, which represents 22 per cent of active ingredient use. In the US, though, large amounts of pesticide are used in the home/garden (17 per cent by value) and in industrial, commercial and government settings (13 per cent by value).

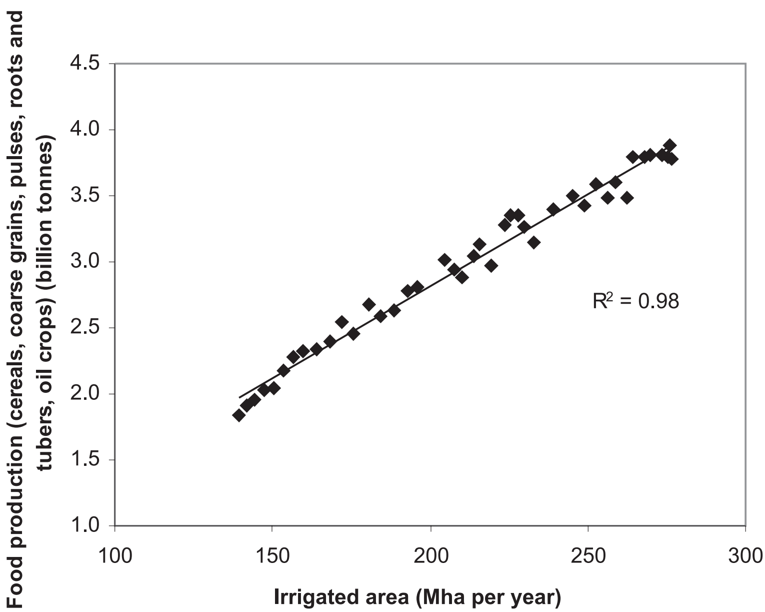
These factors of production have had a direct impact on world food production (Figures 2a–c). There are clear and significant relationships between fertilizer consumption, number of agricultural machines, irrigated area, agricultural land area and arable area with total world food production (comprising all cereals, coarse grains, pulses, roots and tubers, and oil crops). The inefficient use of some of these inputs has, however, led to considerable environmental harm. Increased agricultural area contributes substantially to the loss of habitats, associated biodiversity and their valuable environmental services (MEA, 2005). Some 30–80 per cent of nitrogen applied to farmland escapes to contaminate water systems and the atmosphere, as well as increasing the incidence of some disease vectors (Victor and Reuben, 2002; Smil, 2001; Pretty et al, 2003a; Townsend et al, 2003; Giles, 2005). Irrigation water is often used inefficiently, and causes waterlogging and salinization, as well as diverting water from other domestic and industrial users, and agricultural machinery has increased the consumption of fossil fuels in food production (Leach, 1976; Stout, 1998).

These relationships clearly show the past effectiveness of these factors of production in increasing agricultural productivity. One argument is to suggest that the persistent world food crisis indicates a need for substantially greater use of these inputs (Avery, 1995; Trewevas, 2001; Cassman et al, 2002; Green et al, 2005; Tripp, 2006). But it would be both simplistic and optimistic to assume that



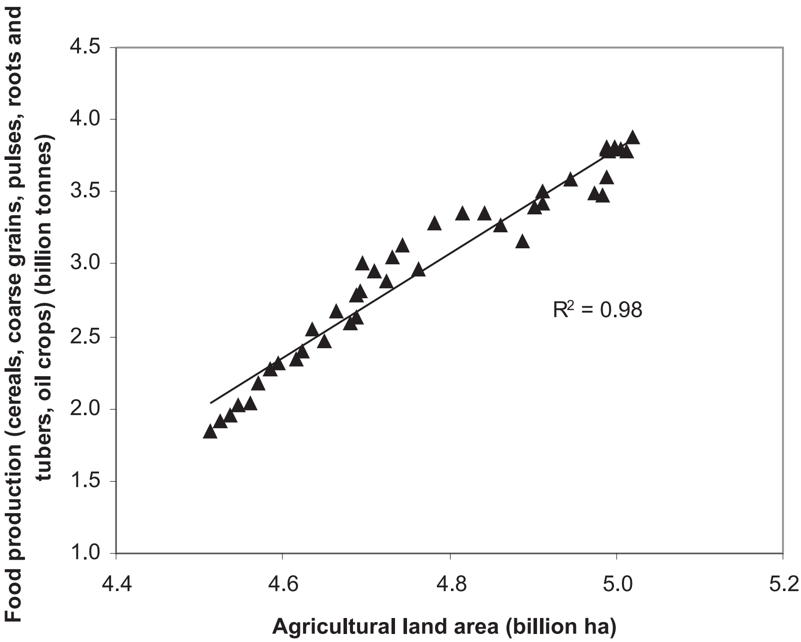
Source: FAO (2005)

Figure 2a *Relationship between all fertilizers applied and world plant food production (1961–2002)*



Source: FAO (2005)

Figure 2b *Relationship between world irrigation area and world plant food production (1961–2002)*



Source: FAO (2005)

Figure 2c *Relationship between world agricultural land area and world plant food production (1961–2002)*

all these relationships will remain linear in the future, and that gains will continue at the previous rates (Tilman, 1999). This would assume a continuing supply of these factors and inputs, and that the environmental costs of their use will be small. There is also growing evidence to suggest that this approach to agricultural growth has reached critical environmental limits, and that the aggregate costs in terms of lost or forgone benefits from environmental services are too great for the world to bear (Ruttan, 1999; MEA, 2005). The costs of these environmental problems are often called externalities, as they do not appear in any formal accounting systems. Yet many agricultural systems themselves are now suffering because key natural assets that they require to be plentiful are being undermined or diminished.

Agricultural systems in all parts of the world will have to make many improvements. In some, the challenge is to increase food production to solve immediate problems of hunger. In others, the focus will be more on adjustments that maintain food production whilst increasing the flow of environmental goods and services. World population is set to continue to increase until about 2040–2050, and then is likely to stabilize or fall because of changes in fertility patterns. The high fertility projection by the UN (2005) is unlikely to arise, as shifts towards lower fertility have already occurred in many countries worldwide, and so there are very real prospects of world population eventually falling over the one to two centuries after the maximum is reached. This suggests that the agricultural and food challenge is likely to be most acute in the next 50–100 years, and thereafter qualitatively change according to people's aggregate consumption patterns.

What is Sustainable Agriculture?

What, then, do we now understand by agricultural sustainability? Many different expressions have come to be used to imply greater sustainability in some agricultural systems over prevailing ones (both pre-industrial and industrialized). These include the terms biodynamic, community-based, ecoagriculture, ecological, environmentally-sensitive, extensive, farm-fresh, free-range, low-input, organic, permaculture, sustainable and wise-use (Pretty, 1995; Conway, 1997; NRC, 2000; McNeely and Scherr, 2003; Clements and Shrestha, 2004; Cox et al, 2004; Gliessman, 2005). There is continuing and intense debate about whether agricultural systems using some of these terms can qualify as sustainable (Balfour, 1943; Lampkin and Padel, 1994; Altieri, 1995; Trewevas, 2001).

Systems high in sustainability can be taken to be those that aim to make the best use of environmental goods and services whilst not damaging these assets (Altieri, 1995; Pretty, 1995, 1998, 2005; Conway, 1997; Hinchliffe et al, 1999; NRC, 2000; Li Wenhua, 2001; Jackson and Jackson, 2002; Tilman et al, 2002; Uphoff, 2002; McNeely and Scherr, 2003; Swift et al, 2004; Tomich et al, 2004; Gliessman, 2004, 2005; MEA, 2005). The key principles for sustainability are to:

(i) integrate biological and ecological processes such as nutrient cycling, nitrogen fixation, soil regeneration, allelopathy, competition, predation and parasitism into food production processes;
(ii) minimize the use of those non-renewable inputs that cause harm to the environment or to the health of farmers and consumers;
(iii) make productive use of the knowledge and problem-solving skills of farmers, so improving their self-reliance and substituting human capital for costly external inputs;
(iv) make productive use of people's collective capacities to work together to solve common agricultural and natural resource problems, such as for pest, watershed, irrigation, forest and credit management.

The idea of agricultural sustainability, though, does not mean ruling out any technologies or practices on ideological grounds. If a technology works to improve productivity for farmers, and does not cause undue harm to the environment, then it is likely to have some sustainability benefits. Agricultural systems emphasizing these principles also tend to be multi-functional within landscapes and economies (Dobbs and Pretty, 2004; MEA, 2005). They jointly produce food and other goods for farmers and markets, but also contribute to a range of valued public goods, such as clean water, wildlife and habitats, carbon sequestration, flood protection, groundwater recharge, landscape amenity value and leisure/tourism. In this way, sustainability can be seen as both relative and case-dependent, and implies a balance between a wide range of potential agricultural and environmental goods and services.

As a more sustainable agriculture seeks to make the best use of nature's goods and services, so technologies and practices must be locally adapted and fitted to place. These are most likely to emerge from new configurations of social capital, comprising relations of trust embodied in new social organizations, and new horizontal and vertical partnerships between institutions, and human capital comprising leadership, ingenuity, management skills and capacity to innovate. Agricultural systems with high levels of social and human assets are more able to innovate in the face of uncertainty (Chambers et al, 1989; Uphoff, 1998; Bunch and Lopez, 1999; Olsson and Folke, 2001; Pretty and Ward, 2001; Gallagher et al, 2005; Bawden, 2005; Folke et al, 2005). This suggests that there are likely to be many pathways towards agricultural sustainability, and further implies that no single configuration of technologies, inputs and ecological management is more likely to be widely applicable than another. Agricultural sustainability implies the need to fit these factors to the specific circumstances of different agricultural systems.

A common, though erroneous, assumption about agricultural sustainability is that it implies a net reduction in input use, so making such systems essentially extensive (they require more land to produce the same amount of food). Recent empirical evidence shows that successful agricultural sustainability initiatives and projects arise from shifts in the factors of agricultural production (e.g. from use of fertilizers to nitrogen-fixing legumes; from pesticides to an emphasis on natural enemies; from ploughing to zero-tillage). A better concept than an extensive system is one that centres on the intensification of resources – making better use of existing resources (e.g. land, water, biodiversity) and technologies (Conway and Pretty, 1991; Pretty et al, 2000; Buttel, 2003; Tegtmeier and Duffy, 2004; Pretty et al, 2006). The critical question centres on the type of intensification. Intensification using natural, social and human capital assets, combined with the use of best available technologies and inputs (best genotypes and best ecological management) that minimize or eliminate harm to the environment, can be termed sustainable intensification.

Capital Assets for Agricultural Systems

What makes agriculture unique as an economic sector is that it directly affects many of the very assets on which it relies for success. Agricultural systems at all levels rely on the value of services flowing from the total stock of assets that they influence and control, and five types of asset, natural, social, human, physical and financial capital, are now recognized as being important. There are, though, some advantages and misgivings with the use of the term capital. On the one hand, capital implies an asset, and assets should be cared for, protected and accumulated over long periods. On the other, capital can imply easy measurability and transferability. Because the value of something can be assigned a monetary value, then it can appear not to matter if it is lost, as the required money could simply be allocated to purchase another asset, or to transfer it from elsewhere. But nature and its wider values are not so easily replaceable as a commodity (Coleman, 1988; Ostrom, 1990; Putnam, 1993; Flora and Flora, 1996; Costanza et al, 1997; Benton, 1998; Scoones, 1998; Uphoff, 1998, 2002; Pretty, 2003). Nonetheless, as terms, natural, social and human capital are useful in helping to shape concepts around basic questions such as what is agriculture for, and what system works best. The five capitals are defined in the following ways:

1 *Natural capital* produces environmental goods and services, and is the source of food (both farmed and harvested or caught from the wild), wood and fibre; water supply and regulation; treatment, assimilation and decomposition of wastes; nutrient cycling and fixation; soil formation; biological control of pests; climate regulation; wildlife habitats; storm protection and flood control; carbon sequestration; pollination; and recreation and leisure (Costanza et al, 1997; MEA, 2005).
2 *Social capital* yields a flow of mutually beneficial collective action, contributing to the cohesiveness of people in their societies. The social assets comprising social capital include norms, values and attitudes that predispose people to cooperate; relations of trust, reciprocity and obligations; and common rules and sanctions mutually agreed or handed down. These are connected and structured in networks and groups (Flora and Flora, 1996; Pretty, 2003; Cramb and Culaseno, 2003).
3 *Human capital* is the total capability residing in individuals, based on their stock of knowledge skills, health and nutrition (Orr, 1992; Byerlee, 1998; Lieblin et al, 2004; Leeuwis, 2004). It is enhanced by access to services that provide these, such as schools, medical services and adult training. People's productivity is increased by their capacity to interact with productive technologies and with other people. Leadership and organizational skills are particularly important in making other resources more valuable.
4 *Physical capital* is the store of human-made material resources, and comprises buildings, such as housing and factories, market infrastructure, irrigation works, roads and bridges, tools and tractors, communications, and energy and transportation systems, that make labour more productive.
5 *Financial capital* is more of an accounting concept, as it serves as a facilitating role rather than as a source of productivity in and of itself. It represents accumulated claims on goods and services, built up through financial systems that gather savings and issue credit, such as pensions, remittances, welfare payments, grants and subsidies.

As agricultural systems shape the very assets on which they rely for inputs, a vital feedback loop occurs from outcomes to inputs (Worster, 1993). Thus sustainable agricultural systems tend to have a positive effect on natural, social and human capital, whilst unsustainable ones feed back to deplete these assets, leaving fewer for future generations. For example, an agricultural system that erodes soil whilst producing food externalizes costs that others must bear. But one that sequesters carbon in soils through organic matter accumulation helps to mediate climate change. Similarly, a diverse agricultural system that enhances on-farm wildlife for pest control contributes to wider stocks of biodiversity, whilst simplified modernized systems that eliminate wildlife do not. Agricultural systems that offer labour-absorption opportunities, through resource improvements or value-added activities, can boost local economies and help to reverse rural-to-urban migration patterns (Carney, 1998; Dasgupta, 1998; Ellis, 2000; Morison et al, 2005; Pretty et al, 2006).

Any activities that lead to improvements in these renewable capital assets thus make a contribution towards sustainability. However, agricultural sustainability does not require that all assets are improved at the same time. One agricultural system that contributes more to these capital assets than another can be said to be more sustainable, but there may still be trade-offs with one asset increasing as another falls. In practice, though, there are usually strong links between changes in natural, social and human capital (Pretty, 2003), with agricultural systems having many potential effects on all three.

Agriculture is, therefore, fundamentally multifunctional. It jointly produces many unique non-food functions that cannot be produced by other economic sectors so efficiently. Clearly, a key policy challenge, for both industrialized and developing countries, is to find ways to maintain and enhance food production. But a key question is: can this be done whilst seeking both to improve the positive side-effects and to eliminate the negative ones? It will not be easy, as past agricultural development has tended to ignore both the multifunctionality of agriculture and the considerable external costs.

Side-effects and Externalities

There are surprisingly few data on the environmental and health costs imposed by agriculture on other sectors and interests. Agriculture can negatively affect the environment through overuse of natural resources as inputs or through their use as a sink for pollution. Such effects are called negative externalities because they are usually non-market effects and therefore their costs are not part of market prices. Negative externalities are one of the classic causes of market failure whereby the polluter does not pay the full costs of their actions, and therefore these costs are called external costs (Baumol and Oates, 1988; Pretty et al, 2000, 2003a; Dobbs and Pretty, 2004).

Externalities in the agricultural sector have at least four features: (i) their costs are often neglected; (ii) they often occur with a time lag; (iii) they often damage groups whose interests are not well represented in political or decision-making processes; and (iv) the identity of the source of the externality is not always known. For example, farmers generally have few incentives to prevent some pesticides escaping to water-bodies, to the atmosphere and to nearby natural systems as they transfer the full cost of cleaning up the environmental consequences to society at large. In the same way, pesticide manufacturers do not pay the full cost of all their products, as they do not have to pay for any adverse side effects that may occur.

Partly as a result of a lack of information, there is little agreement on the economic costs of externalities in agriculture. Some authors suggest that the current system of economic calculations grossly underestimates the current and future value of natural capital (Abramovitz, 1997; Costanza et al, 1997; Daily, 1997; MEA, 2005). However, such valuation of ecosystem services remains controversial because of methodological and measurement problems (Georghiou et al, 1998; Hanley et al, 1998; Farrow et al, 2000; Carson, 2000) and because of the role monetary values have in influencing public opinions and policy decisions.

What has become clear in recent years is that the success of modern agriculture has masked some significant negative externalities, with environmental and health problems recently costed for Ecuador, China, Germany, the Philippines, the UK and the USA (Pingali and Roger, 1995; Crissman et al, 1998; Waibel et al, 1999; Pretty et al, 2000, 2001, 2003a, 2005; Cuyno et al, 2001; Norse et al, 2001; Buttel, 2003; Tegtmeier and Duffy, 2004; Sherwood et al, 2005). These environmental costs begin to change conclusions about which agricultural systems are the most efficient, and suggest that alternatives which reduce externalities should be sought.

Examples of costs in developing countries include The Philippines, where agricultural systems that do not use pesticides result in greater net social benefits because of the reduction in illnesses among farmers and their families, and the associated treatment costs (Rola and Pingali, 1993; Pingali and Roger, 1995). In China, the externalities of pesticides used in rice systems cause US$1.4 billion of costs per year through health costs to people, and adverse effects on both on- and off-farm biodiversity (Norse et al, 2001). In Ecuador, annual mortality in the remote highlands due to pesticides is among the highest reported anywhere in the world at 21 people per 100,000 people, and so the economic benefits of IPM-based systems that eliminate these effects are increasingly beneficial (Sherwood et al, 2005). In the UK, agricultural externalities have been calculated to be some £1.5 billion per year in the late 1990s (Pretty et al, 2000, 2001). These, though, are exceeded by the environmental costs of transporting food from farm to retail outlet to place of consumption – these 'food miles' in the UK result in a further £3.8 billion of environmental costs per year (Pretty et al, 2005).

These data suggest that all types of agricultural systems impose some kinds of costs on the environment. It is, therefore, impossible to draw a boundary between what is and is not sustainable. If the external costs are high and can be reduced by the adoption of new practices and technologies, then this is a move towards sustainability. Agricultural sustainability is thus partly a matter of judgement, which in turn depends on the comparators and baselines chosen. One system may be said to be more sustainable relative to another if its negative externalities are lower. Monetary criteria do, though, only capture some of the values of agricultural systems and the resources upon which they impinge (Carson, 2000), and so choices may depend on wider questions about the sustainability of farm practices (on farm, in field) and the sustainability of whole landscapes (interactions between agricultural and wild habitats) (Green et al, 2005).

Improving Natural Capital for Agroecosystems

Agricultural sustainability emphasizes the potential benefits that arise from making the best use of both genotypes of crops and animals and their agroecological management. Agricultural sustainability does not, therefore, mean ruling out any technologies or practices on ideological grounds (e.g. genetically modified or organic crops) – provided they improve biological and/or economic productivity for farmers, and do not harm the environment (NRC, 2000; Pretty, 2001; Uphoff, 2002; Nuffield Council on Bioethics, 2004). Agricultural sustainability, therefore, emphasizes the potential dividends that can come from making the best use of the genotypes (G) of crops and animals and the ecological (Ec) conditions under which they are grown or raised. The outcome is a result of this G×Ec interaction (Khush et al, 1998). Agricultural sustainability suggests a focus on both genotype improvements through the full range of modern biological approaches, as well as improved understanding of the benefits of ecological and agronomic management, manipulation and redesign.

Agricultural systems, or agroecosystems, are amended ecosystems (Conway, 1985; Gliessman, 1998; 2005; Olsson and Folke, 2001; Dalgaard et al, 2003; Odum and Barrett, 2004; Swift et al, 2004) that have a variety of different properties (Table 2). Modern agricultural systems have amended some of these properties to increase productivity. Sustainable agroecosystems, by contrast, have to seek to shift some of these properties towards natural systems without significantly trading off productivity. Modern agroecosystems have, for example, tended towards high through-flow systems, with energy supplied by fossil fuels directed out of the system (either deliberately for harvests or accidently through side effects). For a transition towards sustainability, renewable sources of energy need to be maximized, and some energy flows directed to fuel essential internal trophic interactions (e.g. to soil organic matter or to weeds for arable birds) so as to maintain other ecosystem functions (Rydberg and Jansén, 2002; Champion et al, 2003; Haberl et al, 2004; Firbank et al, 2005). All annual crops, though, are derived from opportunists, and so their resource use is inherently different to perennials.

Table 2 *Properties of natural ecosystems compared with modern and sustainable agroecosystems*

Property	*Natural ecosystem*	*Modern agroecosystem*	*Sustainable agroecosystem*
Productivity	Medium	High	Medium (possibly high)
Species diversity	High	Low	Medium
Functional diversity	High	Low	Medium–high
Output stability	Medium	Low–medium	High
Biomass accumulation	High	Low	Medium–high
Nutrient recycling	Closed	Open	Semi-closed
Trophic relationships	Complex	Simple	Intermediate
Natural population regulation	High	Low	Medium–high
Resilience	High	Low	Medium
Dependence on external inputs	Low	High	Medium
Human displacement of ecological processes	Low	High	Low–medium
Sustainability	High	Low	High

Source: Gliessman, 2005

Modern agriculture has also come to rely heavily on nutrient inputs obtained from or driven by fossil fuel-based sources. Nutrients are also used inefficiently, and together with certain products (e.g. ammonia, nitrate, methane, carbon dioxide), are lost to the environment. For sustainability, nutrient leaks need to be reduced to a minimum, recycling and feedback mechanisms introduced and strengthened, and nutrients and materials diverted to capital accumulation. Agroecosystems are considerably more simplified than natural ecosystems, and loss of biological diversity (to improve crop and livestock productivity) results in the loss of some ecosystem services, such as pest and disease control (Gallagher et al, 2005). For sustainability, biological diversity needs to be increased to recreate natural control and regulation functions, and to manage pests and diseases rather than seeking to eliminate them. Mature ecosystems are now known to be not stable and unchanging, but in a state of dynamic equilibrium that buffers against large shocks and stresses. Modern agroecosystems have weak resilience, and for transitions towards sustainability need to focus on structures and functions that improve resilience (Holling et al, 1998; Folke et al, 2005).

But converting an agroecosystem to a more sustainable design is complex, and generally requires a landscape or bioregional approach to restoration or management (Kloppenburg et al, 1996; Higgs, 2003; Jordan, 2003; Odum and Barrett, 2004; Swift et al, 2004; Terwan et al, 2004). An agroecosystem is a bounded system designed to produce food and fibre, yet it is also part of a wider landscape at which scale a number of ecosystem functions are important (Gliessman, 2005). For sustainability, interactions need to be developed between agroecosystems and whole landscapes of other farms and non-farmed or wild habitats (e.g. wetlands, woods, riverine habitats), as well as social systems of food procurement. Mosaic landscapes with a variety of farmed and non-farmed habitats are known to be good for birds as well as farms (Bignall and McCracken, 1996; Shennan et al, 2005; Woodhouse et al, 2005).

There are several types of resource-conserving technologies and practices that can be used to improve the stocks and use of natural capital in and around agro-ecosystems. These are:

1 *Integrated pest management*, which uses ecosystem resilience and diversity for pest, disease and weed control, and seeks only to use pesticides when other options are ineffective (e.g. Lewis et al, 1997; Gallagher et al, 2005; Herren et al, 2005).
2 *Integrated nutrient management*, which seeks both to balance the need to fix nitrogen within farm systems with the need to import inorganic and organic sources of nutrients, and to reduce nutrient losses through erosion control (Crews and Peoples, 2004; Leach et al, 2004).
3 *Conservation tillage*, which reduces the amount of tillage, sometime to zero, so that soil can be conserved and available moisture used more efficiently (Petersen et al, 2000; Holland, 2004).
4 *Agroforestry*, which incorporates multifunctional trees into agricultural systems, and collective management of nearby forest resources (Leakey et al, 2005).
5 *Aquaculture*, which incorporates fish, shrimps and other aquatic resources into farm systems, such as into irrigated rice fields and fish ponds, and so leads to increases in protein production (Bunting, 2007).
6 *Water harvesting* in dryland areas, which can mean formerly abandoned and degraded lands can be cultivated, and additional crops grown on small patches of irrigated land owing to better rain water retention (Pretty, 1995; Reij, 1996).
7 *Livestock integration* into farming systems, such as dairy cattle, pigs and poultry, including using zero-grazing cut and carry systems (Altieri, 1995).

Many of these individual technologies are also multifunctional (Pretty, 1995; Lewis et al, 1997). This implies that their adoption should mean favourable changes in several components of the farming system at the same time. For example, hedgerows and alley crops encourage predators and act as windbreaks, so reducing soil erosion. Legumes introduced into rotations fix nitrogen, and also act as a break crop to prevent carry-over of pests and diseases. Grass contour strips slow surface water run-off, encourage percolation to groundwater, and can be a source of fodder for livestock. Catch crops prevent soil erosion and leaching during critical periods, and can also be ploughed in as a green manure. The incorporation of green manures not only provides a readily available source of nutrients for the growing crop but also increases soil organic matter and hence water retentive capacity, further reducing susceptibility to erosion.

Although many resource-conserving technologies and practices are currently being used, the total number of farmers using them worldwide is still relatively small. This is because their adoption is not a costless process for farmers. They cannot simply cut their existing use of fertilizer or pesticides and hope to maintain outputs, so making operations more profitable. They also cannot simply introduce a new productive element into their farming systems, and hope it succeeds. These transition costs arise for several reasons. Farmers must first invest in learning (Orr, 1992; Röling and Wagermakers, 1997; Bentley et al, 2003; Lieblin et al, 2004; Bawden, 2005; Chambers, 2005). As recent and current policies have tended to promote specialized, non-adaptive systems with a lower innovation capacity, so farmers have to spend time learning about a greater diversity of practices and measures (Gallagher et al, 2005). Lack of information and management skills is, therefore, a major barrier to the adoption of sustainable agriculture. During the transition period, farmers must experiment more, and so incur the costs of making mistakes as well as of acquiring new knowledge and information.

The on-farm biological processes that make sustainable agroecosystems productive also take time to become established. These include the rebuilding of depleted natural buffers of predator stocks and wild host plants; increasing the levels of nutrients; developing and exploiting microenvironments and positive interactions between them; and the establishment and growth of trees. These higher variable and capital investment costs must be incurred before returns increase. Examples include costs for: labour in the construction of soil and water conservation measures; the planting of trees and hedgerows; pest and predator monitoring and management; fencing of paddocks; the establishment of zero-grazing units; and the purchase of new technologies, such as manure storage equipment or global positioning systems for tractors.

It has also been argued that farmers adopting more sustainable agroecosystems are internalizing many of the agricultural externalities associated with intensive farming, and so could be compensated for effectively providing environmental goods and services. Providing such compensation or incentives would be likely to increase the adoption of resource conserving technologies (Dobbs and Pretty, 2004). Nonetheless, periods of lower yields seem to be more apparent during conversions of industrialized agroecosystems. There is growing evidence to suggest that most pre-industrial and modernized farming systems in developing countries can make rapid transitions to both sustainable and productive farming.

Social Learning and Asset Building

The term participation is now part of the normal language of most development and conservation agencies. It has become such a fashion that almost everyone says that it is part of their work. This has created many paradoxes, as it is easy to misinterpret the term. In conventional development, participation has commonly centred on encouraging local people to contribute their labour in return for food, cash or materials. But material incentives distort perceptions, create dependencies, and give the misleading impression that local people are supportive of externally driven initiatives. When little effort is made to build local interests and capacity, then people have no stake in maintaining structures or practices once the flow of incentives stops. If people do not cross a cognitive frontier, then there will be no ecological literacy.

The dilemma for authorities is that they both need and fear people's participation. They need people's agreement and support, but they fear that wider and open-ended involvement is less controllable. But if this fear permits only stage-managed forms of participation, then distrust and greater alienation are the most likely outcomes. Participation can mean finding something out and proceeding as originally planned. Alternatively, it can mean developing processes of collective learning that change the way that people think and act. The many ways that organizations interpret and use the term participation range from passive participation, where people are told what is to happen and act out predetermined roles, to self-mobilization, where people take initiatives independently of external institutions (Pretty, 1995).

Agricultural development often starts with the notion that there are technologies that work, and so it is just a matter of inducing or persuading farmers to adopt them (Leeuwis, 2004). But the problem is that the imposed models look good at first, and then tend to fade away (Kerr et al, 1999). Alley cropping, an agroforestry system comprising rows of nitrogen-fixing trees or bushes separated by rows of cereals, has long been the focus of research. Many productive and sustainable systems, needing few or no external inputs, have been developed. They stop erosion, produce food and wood, and can be cropped over long periods. But the problem is that very few farmers have adopted these systems as designed – they appear to have been produced as suitable largely only for research stations, with their plentiful supplies of labour and resources and standardized soil conditions.

It is critical that sustainable agriculture and conservation management do not prescribe concretely defined sets of technologies and practices. This only serves to restrict the future options of farmers and rural people. As conditions change and as knowledge changes, so must the capacity of farmers and communities be enhanced to allow them to change and adapt too. Agricultural sustainability should not imply simple models or packages to be imposed. Rather it should be seen as a process of social learning, and emergent technologies fitted to specific local circumstances. This centres on building the capacity of farmers and their communities to learn about the complex ecological and biophysical complexity in their fields and farms, and then to act on this information. The process of learning, if it is socially embedded and jointly engaged upon, provokes changes in behaviour and can bring forth a new world (Maturana and Varela, 1992).

What lessons have we learned from programmes that successfully promote social learning and sustainable natural resource management? The first is that sustainability is an emergent property of systems high in social, human and natural capital. When these assets are in decline, then we are retreating from sustainability. Next is the recognition that farmers can improve their agroecological understanding of the complexities of their farms and related ecosystems, and that new information can lead to improved agricultural outcomes. In turn, increased understanding is also an emergent property, derived in particular from farmers engaging in their own experimentation, supported by scientists and extensionists, leading to the development of novel technologies and practices. These are more likely to spread from farmer to farmer, and from group to group. These conclusions strongly suggest that social learning processes should become an important focus for all agricultural and natural resource management programmes, and that professionals should make every effort to appreciate both the complementarity of such social processes with sustainable technology development and spread, and the subtlety and care required in their implementation.

What can be done both to encourage the greater adoption of group-based programmes for environmental improvements, and to identify the necessary support for groups to evolve to maturity, and thence to spread and connect with others? Clearly, international agencies, governments, banks and non-government organizations should invest more in social and human capital creation. It is not costless to build human capital and establish new forms of organization and social capital. The main danger lies in being satisfied with any degree of partial progress, and so not going far enough. Of course, group-based approaches alone are not sufficient conditions for achieving sustainable natural resource management. Policy reform is an additional requirement for shaping the wider context, in order to make it more favourable to the emergence and sustenance of local groups. This has clearly worked in countries such as India, Sri Lanka and Australia.

One way to ensure the stability of social connectedness is for groups to work together by federating to influence district, regional or even national bodies. This can open up economies of scale to bring greater economic and ecological benefits. The emergence of such federated groups with strong leadership also makes it easier for government and non-governmental organizations to develop direct links with poor and formerly excluded groups, although if these groups were dominated by the wealthy, the opposite would be true. This could result in greater empowerment of poor households, as they draw on public services more efficiently. Such interconnectedness between groups is more likely to lead to improvements in natural resources than regulatory schemes alone (Röling and Wagemakers, 1997; Dobbs and Pretty, 2004).

But this raises further questions. How, too, can policy makers protect existing programmes in the face of new threats? What will happen to state–community relations when social capital in the form of local associations and their federated bodies spreads to very large numbers of people? Will the state colonize these groups, or will new broad-based forms of democratic governance emerge? Important questions also relate to the groups themselves. Good programmes may falter if individuals start to 'burn out', feeling that investments in social capital are no longer paying. It is vitally important that policy makers and practitioners continue to seek ways to provide support for the processes that both help groups to form, and help them mature along the lines that local people desire and need, and from which natural environments will benefit.

There are also persistent concerns that the establishment of new community institutions and users' groups may not always benefit the poor. There are signs that they can all too easily become a new rhetoric without fundamentally improving equity and natural resources. If, for example, joint forest management becomes the new order of the day for foresters, then there is a very real danger that some will coerce local people into externally run groups so that targets and quotas are met. This is an inevitable part of any transformation process. The old guard adopts the new language, implies they were doing it all the time, and nothing really changes. But this is not a reason for abandoning the new. Just because some groups are captured by the wealthy, or are run by government staff with little real local participation, does not mean that all are fatally flawed. What it does show clearly is that the critical frontiers are inside us. Transformations must occur in the way we all think if there are to be real and large-scale transformations in the land and the lives of people.

Effects of Sustainable Agriculture on Yields

One persistent question regarding the potential benefits of more sustainable agroecosystems centres on productivity trade-offs. If environmental goods and services are to be protected or improved, what then happens to productivity? If it falls, then more land will be required to produce the same amount of food, thus resulting in further losses of natural capital (Green et al, 2005). As indicated earlier, the challenge is to seek sustainable intensification of all resources in order to improve food production. In industrialized farming systems, this has proven to be impossible to do with organic production systems, as food productivity is lower for both crop and livestock systems (Lampkin and Padel, 1994; Caporali et al, 2003). Nonetheless, there are now some 3Mha of agricultural land in Europe managed with certified organic practices. Some have led to lower energy use (though lower yields too); others to better nutrient retention, and some greater nutrient losses (Dalgaard et al, 1998, 2002; Løes and Øgaard, 2003; Gosling and Shepherd, 2004), and some to greater labour absorption (Morison et al, 2005).

Many other farmers have adopted integrated farming practices, which represent a step or several steps towards sustainability. What has become increasingly clear is that many modern farming systems are wasteful, as integrated farmers have found they can cut down many purchased inputs without losing out on profitability (EA, 2005). Some of these cuts in use are substantial, others are relatively small. By adopting better targeting and precision methods, there is less wastage and so more benefit to the environment. They can then make greater cuts in input use once they substitute some regenerative technologies for external inputs, such as legumes for inorganic fertilizers or predators for pesticides. Finally, they can replace some or all external inputs entirely over time once they have learned their way into a new type of farming characterized by new goals and technologies (Pretty and Ward, 2001).

What is clear is that resource-conserving and regenerative technologies are spreading. In Denmark, some 150 farms have in-field weather stations to help predict disease outbreaks in potatoes, leading to cuts in fungicide use, with some growers able to postpone first applications for five or more weeks. In the UK, some 150,000 hectares of cereal farms were computer-mapped in the early 2000s, enabling inputs to be targeted more precisely and the total use of pesticide and fertilizer to be cut. Also in the UK, three-quarters of crops grown in glasshouses use natural predators to control pests rather than pesticides. In France, there are 700 farms in the national network researching and implementing 'agriculture durable'. In the state of Baden-Württemberg in southern Germany, 100,000 farms are using sustainable practices and technologies, though not all are integrated at the whole farm level. In Australia, one third of all farmers are members of Landcare groups. The organic revolution also continues, with demand from consumers growing, and the number of farmers converted entirely to organic practices in industrialized countries continues to grow rapidly.

However, it is in developing countries that some of the most significant progress towards sustainable agroecosystems has been made in the past decade (Uphoff, 2002; McNeely and Scherr, 2003; Pretty et al, 2003b). The largest study comprised the analysis of 286 projects in 57 countries (Pretty et al, 2006). This involved the use of both questionnaires and published reports by projects to assess changes over time. As in earlier research (Pretty et al, 2003b), data were triangulated from several sources, and cross-checked by external reviewers and regional experts. The study involved analysis of projects sampled once in time ($n = 218$) and those sampled twice over a 4-year period ($n = 68$). Not all proposed cases were accepted for the dataset, and rejections were based on a strict set of criteria. As this was a purposive sample of 'best practice' initiatives, the findings are not representative of all developing country farms.

Table 3 contains a summary of the location and extent of the 286 agricultural sustainability projects across the eight categories of FAO farming systems (Dixon et al, 2001) in the 57 countries. In all, some 12.6 million farmers on 37 million hectares were engaged in transitions towards agricultural sustainability in these 286 projects. This is just over 3 per cent of the total cultivated area (1136 million ha) in developing countries. The largest number of farmers was in wetland rice-based systems, mainly in Asia (category 2), and the largest area was in dualistic mixed systems, mainly in southern Latin America (category 6). This study showed that agricultural sustainability was spreading to more farmers and hectares. In the 68 randomly re-sampled projects from the original study, there was a 54 per cent increase over the four years in the number of farmers, and 45 per cent in the number of hectares. These resurveyed projects comprised 60 per cent of the farmers and 44 per cent of the hectares in the original sample of 208 projects.

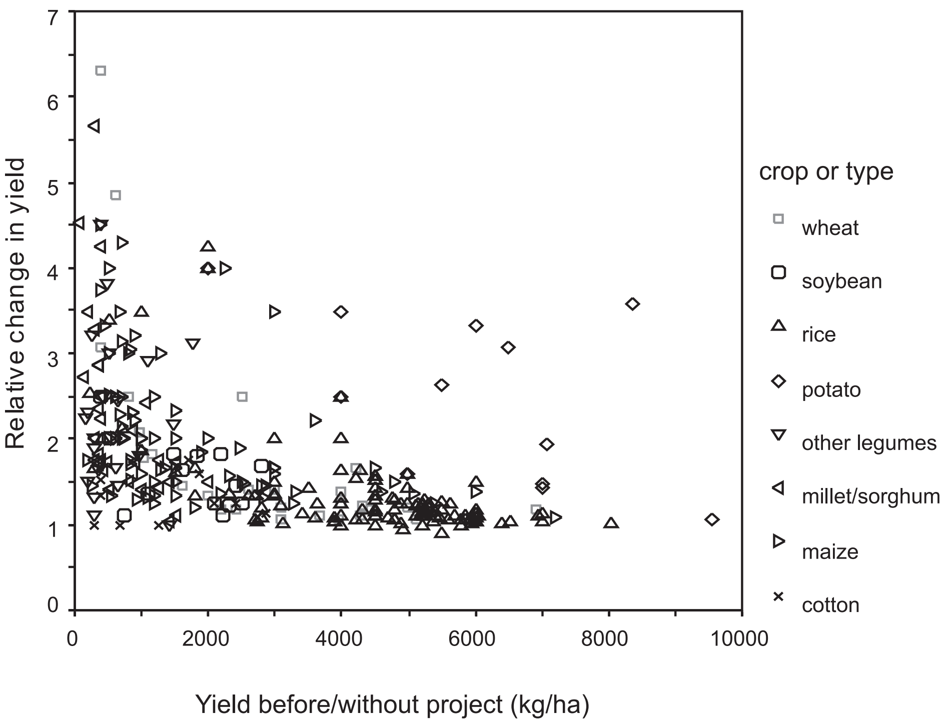
Table 3 *Summary of adoption and impact of agricultural sustainability technologies and practices on 286 projects in 57 countries*

FAO farm system category[1]	*Number of farmers adopting*	*Number of hectares under sustainable agriculture*	*Average % increase in crop yields*[2]
1. Smallholder irrigated	177,287	357,940	129.8 (±21.5)
2. Wetland rice	8,711,236	7,007,564	22.3 (±2.8)
3. Smallholder rainfed humid	1,704,958	1,081,071	102.2 (±9.0)
4. Smallholder rainfed highland	401,699	725,535	107.3 (±14.7)
5. Smallholder rainfed dry/cold	604,804	737,896	99.2 (±12.5)
6. Dualistic mixed	537,311	26,846,750	76.5 (±12.6)
7. Coastal artisanal	220,000	160,000	62.0 (±20.0)
8. Urban-based and kitchen garden	207,479	36,147	146.0 (±32.9)
All projects	12,564,774	36,952,903	79.2 (±4.5)

[1] Farm categories from Dixon et al (2001).
[2] Yield data from 360 crop-project combinations; reported as % increase (thus a 100% increase is a doubling of yields). Standard errors in brackets.

For the 360 reliable yield comparisons from 198 projects, the mean relative yield increase was 79 per cent across the very wide variety of systems and crop types. However, there was a wide spread in results (Figure 3). While 25 per cent of projects reported relative yields greater than 2.0 (i.e. 100 per cent increase), half of all the projects had yield increases of between 18 per cent and 100 per cent. The geometric mean is a better indicator of the average for such data with a positive skew, but this still shows a 64 per cent increase in yield. These sustainable agroecosystems also have positive side effects, helping to build natural capital, strengthen communities (social capital) and develop human capacities (Ostrom, 1990; Pretty, 2003). Examples of positive side effects recently recorded in various developing countries include:

- improvements to natural capital, including increased water retention in soils, improvements in water table (with more drinking water in the dry season), reduced soil erosion combined with improved organic matter in soils, leading to better carbon sequestration, and increased agro-biodiversity;
- improvements to social capital, including more and stronger social organizations at local level, new rules and norms for managing collective natural resources, and better connectedness to external policy institutions;
- improvements to human capital, including more local capacity to experiment and solve own problems; reduced incidence of malaria in rice–fish zones,



Note: Only field crops with $n > 9$ are shown.

Figure 3 *Relationship between relative changes in crop yield after (or with project) to yield before (or without project)*

> increased self-esteem in formerly marginalized groups, increased status of women, better child health and nutrition, especially in dry seasons, and reversed migration and more local employment.

What we do not know, however, is the full economic benefits of these spin-offs. In many industrialized countries, agriculture is now assumed to contribute very little to GDP, leading many commentators to assume that agriculture is not important for modernized economies (NRC, 2000). But such a conclusion is a function of the fact that too few measures are being made of the positive side effects of agriculture (MEA, 2005). In poor countries, where financial support is limited and markets weak, then people rely even more on the value they can derive from the natural environment and from working together to achieve collective outcomes.

Effects of Sustainable Agriculture on Pesticide Use and Yields

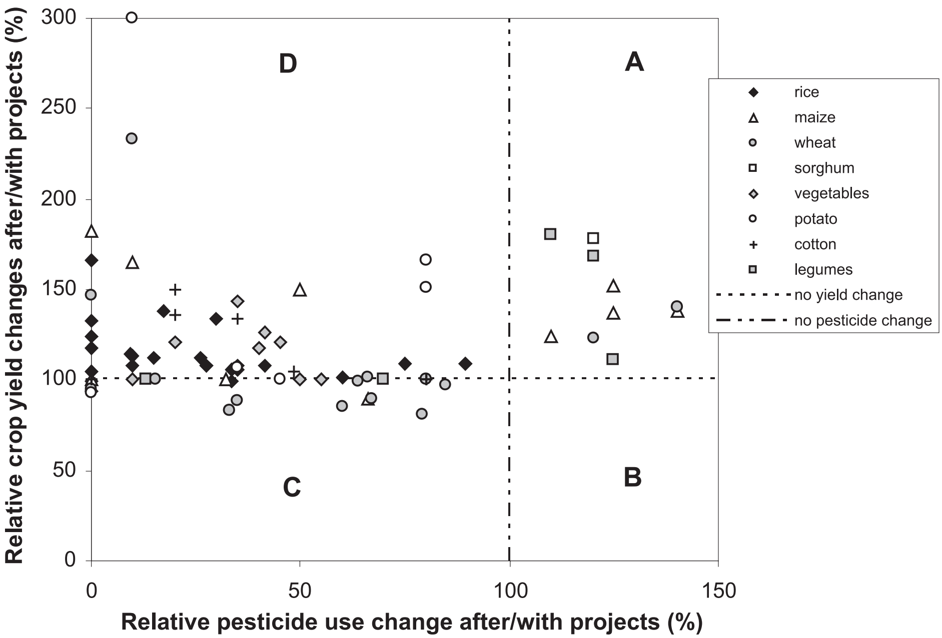
Recent integrated pest management (IPM) programmes, particularly in developing countries, are beginning to show how pesticide use can be reduced and pest management practices can be modified without yield penalties (Heong et al, 1999; Brethour and Weerskink, 2001; Wilson and Tisdell, 2001; Gallagher et al, 2005; Herren et al, 2005; Pretty and Waibel, 2005). In principle, there are four possible trajectories of impact if IPM is introduced:

1 both pesticide use and yields increase (A);
2 pesticide use increases but yields decline (B);
3 both pesticide use and yields fall (C);
4 pesticide use declines, but yields increase (D).

The assumption in modern agriculture is that pesticide use and yields are positively correlated. For IPM, the trajectory moving into sector A is therefore unlikely but not impossible, for example in low-input systems. What is expected is a move into sector C. While a change into sector B would be against economic rationale, farmers are unlikely to adopt IPM if their profits would be lowered. A shift into sector D would indicate that current pesticide use has negative yield effects or that the amount saved from pesticides is reallocated to other yield increasing inputs. This could be possible with an excessive use of herbicides or when pesticides cause outbreaks of secondary pests, such as observed with the brown plant hopper in rice (Kenmore et al, 1984).

Figure 4 shows data from 62 IPM initiatives in 26 developing and industrialized countries (Australia, Bangladesh, China, Cuba, Ecuador, Egypt, Germany, Honduras, India, Indonesia, Japan, Kenya, Laos, Nepal, the Netherlands, Pakistan, the Philippines, Senegal, Sri Lanka, Switzerland, Tanzania, Thailand, the UK, the USA, Vietnam and Zimbabwe) (Pretty and Waibel, 2005). The 62 IPM initiatives have some 5.4 million farm households on 25.3Mha. The evidence on pesticide use is derived from data on both the number of sprays per hectare and the amount of active ingredient used per hectare. This analysis does not include recent evidence on the effect of some genetically modified crops, some of which result in reductions in the use of herbicides (Champion et al, 2003) and pesticides (Nuffield Council on Bioethics, 2004), and some of which have led to increases (Benbrook, 2003).

There is only one sector B case reported in recent literature (Feder et al, 2004). Such a case has recently been reported from Java for rice farmers. The cases in sector C, where yields fall slightly while pesticide use falls dramatically, are mainly cereal farming systems in Europe, where yields typically fall to some 80 per cent of current levels while pesticide use is reduced to 10–90 per cent of current levels (Pretty, 1998; Röling and Wagemakers, 1997). Sector A contains 10 projects where



Note: Data from 80 crop combinations, 62 projects, 26 countries.

Figure 4 *Association between pesticide use and crop yields*

total pesticide use has indeed increased in the course of IPM introduction. These are mainly in zero-tillage and conservation agriculture systems, where reduced tillage creates substantial benefits for soil health and reduces off-site pollution and flooding costs. These systems usually require an increased use of herbicides for weed control (de Freitas, 1999), although there are some examples of organic zero-tillage systems (Petersen et al, 2000). Over 60 per cent of the projects are in category D where pesticide use declines and yields increase. While pesticide reduction is to be expected, as farmers substitute pesticides by information, yield increases induced by IPM are a more complex issue. It is likely, for example, that farmers who receive good quality field training will not only improve their pest management skills but also become more efficient in other agronomic practices such as water, soil and nutrient management. They can also invest some of the cash saved from pesticides in other inputs such as higher quality seeds and inorganic fertilizers.

Effects on Carbon Balances

The 1997 Kyoto Protocol to the UN Framework Convention on Climate Change established an international policy context for the reduction of carbon emissions and increases in carbon sinks in order to address the global challenge of anthropogenic interference with the climate system. It is clear that both emission reductions and sink growth will be necessary for mitigation of current climate change trends (Watson et al, 2000; IPCC, 2001, 2007; Royal Society, 2001; Swingland, 2003; Oelbermann et al, 2004). A source is any process or activity that releases a greenhouse gas, or aerosol or a precursor of a greenhouse gas into the atmosphere, whereas a sink is a mechanism that removes these from the atmosphere. Carbon sequestration is defined as the capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere. Agricultural systems emit carbon through the direct use of fossil fuels in food production, the indirect use of embodied energy in inputs that are energy-intensive to manufacture, and the cultivation of soils and/or soil erosion resulting in the loss of soil organic matter. Agriculture also contributes to climate change through emissions of methane from irrigated rice systems and ruminant livestock. The direct effects of land use and land use change (including forest loss) have led to a net emission of 1.7Gt C yr^{-1} in the 1980s and 1.6Gt C yr^{-1} in the 1990s (Watson et al, 2000; Bellamy et al, 2005).

On the other hand, agriculture can also be an accumulator of carbon when organic matter is accumulated in the soil, and when above-ground biomass acts either as a permanent sink or is used as an energy source that substitutes for fossil fuels and so avoids carbon emissions. There are three main mechanisms and 21 technical options (Table 4) through which positive actions can be taken by farmers by:

A increasing carbon sinks in soil organic matter and above-ground biomass;
B avoiding carbon dioxide or other greenhouse gas emissions from farms by reducing direct and indirect energy use;
C increasing renewable energy production from biomass that either substitutes for consumption of fossil fuels or replaces inefficient burning of fuelwood or crop residues, and so avoids carbon emissions.

Social Outcomes in Developing Countries

At some locations, agroecological approaches have had a significant impact on labour markets. Some practices result in increased on-farm demand for labour (e.g. water harvesting in Niger), whilst others actually reduce labour demand (e.g. zero-tillage in Brazil). Some result in the opening up of whole new seasons for agricultural production, particularly in dryland contexts, through improved harvesting of rainfall, leading to much greater demand for labour. Migration reversals can also occur when wage labour opportunities increase as part of the project (e.g. watershed improvements), when more productive agriculture leads to higher wages and employment, when there are higher returns to agriculture, and when there are

Table 4 *Mechanisms for increasing carbon sinks and reducing CO_2 and other greenhouse gas emissions in agricultural systems*

Mechanism A. Increase carbon sinks in soil organic matter and above-ground biomass
• Replace inversion ploughing with conservation- and zero-tillage systems
• Adopt mixed rotations with cover crops and green manures to increase biomass additions to soil
• Adopt agroforestry in cropping systems to increase above-ground standing biomass
• Minimize summer fallows and periods with no ground cover to maintain soil organic matter stocks
• Use soil conservation measures to avoid soil erosion and loss of soil organic matter
• Apply composts and manures to increase soil organic matter stocks
• Improve pasture/rangelands through grazing, vegetation and fire management both to reduce degradation and increase soil organic matter
• Cultivate perennial grasses (60–80% of biomass below ground) rather than annuals (20% below ground)
• Restore and protect agricultural wetlands
• Convert marginal agricultural land to woodlands to increase standing biomass of carbon
Mechanism B. Reduce direct and indirect energy use to avoid greenhouse gas emissions (CO_2, CH_4 and N_2O)
• Conserve fuel and reduce machinery use to avoid fossil-fuel consumption
• Use conservation or zero-tillage to reduce CO_2 emissions from soils
• Adopt grass-based grazing systems to reduce methane emissions from ruminant livestock
• Use composting to reduce manure methane emissions
• Substitute biofuel for fossil fuel consumption
• Reduce the use of inorganic N fertilizers (as manufacture is highly energy-intensive), and adopt targeted- and slow-release fertilizers
• Use integrated pest management to reduce pesticide use (avoid indirect energy consumption)
Mechanism C. Increase biomass-based renewable energy production to avoid carbon emissions
• Cultivate annual crops for biofuel production, such as ethanol from maize and sugar cane
• Cultivate annual and perennial crops, such as grasses and coppiced trees, for combustion and electricity generation, with crops replanted each cycle for continued energy production
• Use biogas digesters to produce methane, so substituting for fossil fuel sources
• Use improved cookstoves to increase efficiency of biomass fuels

Source: Pretty et al, 2002

overall improvements in village conditions, such as infrastructure and services. Improvements in urban gardening have led to increases in employment (Funes et al, 2002).

There are several documented cases where these approaches have helped to reverse seasonal or even long-term migration. In the Guinope and Cantarranas regions of Honduras, families returned from the capital city to take up labour opportunities brought by rural economic growth centred on improved agricultural productivity. In India, seasonal migration from a number of rainfed projects (e.g. in Maharashtra, Gujarat and Tamil Nadu) declined as sufficient water becomes available to crop in the dry season, with women in particular benefiting from being able to remain at home all year. In Niger, young men have been able to form labour-societies to meet the demand for water-harvesting construction, rather than migrate to the coast for work (Reij, 1996; Bunch and Lopez, 1999; Pretty, 2002; Kabore and Reij, 2004)

However, in some locations increasing labour requirements may be an impediment to adoption, and farmers may actually desire labour-saving technologies and practices. All transformations in agricultural systems are costly, thus always mitigating against the poorest households and economies. Given the appropriate institutional conditions, poor households may, however, be able to make use of new configurations of human and social capital to make more productive use of natural capital and available technologies. In some areas, but not all, this also means an increase in on-farm labour requirements. Within households, such additional labour is often supplied by women rather than men.

Where labour is scarce, such as in HIV-affected populations, or where women suffer a particularly heavy double load of domestic and agricultural labour, or when there are significant off-farm labour opportunities (e.g. 52 per cent of rural household income in Latin America comes from non-agricultural employment) then technologies for agricultural sustainability will either need to emphasize labour saving or result in sufficiently high productivity gains that labour can be hired. Examples of the former include zero-tillage using herbicides for weed control in Brazil and Argentina, and legumes as green manures and cover crops in Central America. Examples of the latter include raised-bed vegetable technology for women's groups in East Africa and fish-raising in paddy fields in South Asia.

What we do not know is how internal labour markets will affect incentives to work in agriculture and rural regions, and how best to promote regional rural development based on agricultural intensification. Sustainable agriculture has the potential directly and indirectly to influence the health of rural people. In the first instance, improved food supply throughout the year has a fundamental impact on health, which in turn allows adults to be more productive, and children to attend school and still be able to concentrate on learning. In Kenya, for example, the simple technology of double-dug beds has improved domestic food supply for several tens of thousands of households by producing a year-round supply of vegetables. It is children who have been noted as major beneficiaries.

In some cases, a more sustainable agriculture can also help to remove threats to health in the environment – such as consumption of mosquito larva by fish in rice fields – with measurable reductions in malaria incidence recorded in China. In Jiangsu Province, there has been rapid growth of rice aquaculture: from about

5000ha in 1994 to 117,000ha of rice–fish, rice–crab and rice–shrimp systems. Rice yields have increased by 10–15 per cent, but the greatest dividend is in protein: each mu (one fifteenth of a hectare) can produce 50kg of fish (Li Wenhua, 2001). Additional benefits come from reduced insecticide use, and measured reductions in malaria incidence owing to fish predation of mosquito larvae.

Sustainable agriculture can also have an indirect effect on reproductive health. Where women are organized into groups, such as for microfinance delivery (credit and savings), livestock raising or watershed development, such social capital creation offers opportunities or 'entry points' for other sectors to interact closely with women. In Ecuador, for example, the World Neighbors (WN) programme working with remote rural communities on sustainable agriculture and natural resource management made a substantial impact on family planning. WN actively compared two types of programme in Guaranda canton, Bolivar Province, by working in six communities that only received health input, and another six that received an integrated programme involving soil and water conservation, green manures, vegetable gardening and farmer-experimentation with barley, wheat, maize and potato varieties, combined with group formation. The health interventions yielded few results. But the integrated approach brought pronounced changes in attitudes and values. Contraceptive use in these communities was double that in the 'health only' villages. The family planning clinic, on the verge of closure in 1992, provided 18,000 consultations in 1998 (Ruddell, 1995; Hinchcliffe et al, 1999; Uphoff, 2002).

In Nepal, World Neighbors also found that reproductive health and family planning were not effective entry points. Instead, women's reproductive health, status, work and fertility could be better addressed by forming and working with women's savings and credit groups that could participate in planning a wide range of development activities. Confident groups with better literacy, income and food security were able to challenge traditional roles and norms, leading to capacity to deal directly with reproductive health.

In certain circumstances, sustainable agriculture practices appear to be currently more accessible to larger farmers – particularly the zero-tillage systems in Argentina, Brazil and Paraguay. However, evidence from Paraguay and Brazil also suggests that larger numbers of small farmers are now adopting and adapting elements of these practices. It is important to note that adoption of conservation agriculture by large farmers may still result in significant regional change: 'zero-tillage has been a major factor in changing the top-down nature of agricultural services to farmers towards a participatory, on-farm approach' (John Landers, pers. comm.). But in other contexts, sustainable agriculture has first been adopted by small farmers, and is only now spreading to larger ones once they have seen the initial success. In Bangladesh, the rice–fish and rice–IPM technologies were adopted by very small farmers first, with larger farmers attracted only when success had been proven.

Can agroecological approaches result in improvements in livelihoods for landless families and the core poor? There are three possibilities: improvements to labour markets, improved access to land through land reform, or changed social norms that encourage greater equity and sharing. The first of these seems more likely than the others – though as noted above, some sustainable agriculture applications are favoured by farm families precisely because they reduce labour requirements. There is some evidence that social capital formation can result in new equitable arrangements within communities. Landless families, for example, have been given new opportunities to join farmers' groups in western and central Kenya. Such changes cannot be directly attributed to sustainable agriculture – rather it is due to changes in values and norms arising from new configurations of local social capital.

Is There a Place for Genetic Modification?

Only a few years after the development of the first genetically modified crops for agriculture, opinions on benefits and risk remain sharply divided. Some argue that genetically modified organisms are safe and essential for world progress; others state they are not needed, and hold too many risks. The first group believes that media manipulation and scaremongering are limiting useful technologies; the second that scientists, private companies and regulators are understating hazards for the sake of economic returns.

Neither view is entirely correct, for one simple reason. Genetically modified organisms are not a single, simple technology (Pretty, 2001; GM Science Review, 2003; Nuffield Council on Bioethics, 2004). Each product brings different potential benefits for different stakeholders; each poses different environmental and health risks. It is, therefore, useful to distinguish between different generations of genetically modified technologies. The first generation technologies came into commercial use in the late 1990s and early 2000s, and have tended not to bring distinct consumer benefits, one reason why there is so much current public opposition. The realization of promised benefits to farmers and the environment has only been patchy. First generation technologies include herbicide-tolerant crops, insect-resistant crops, long-life tomatoes, bacteria in containment for the production of cheese and washing-powder enzymes, and flowers with amended colour.

The second generation technologies comprise those already developed and tested, but not yet commercially released on a large scale, either because of uncertainties over the stability of the technology itself, or over concerns for potential environmental risks. Some of these applications are likely to bring more public and consumer benefits, and include a range of medical applications. These include viral resistance in rice, cassava, papaya, sweet potatoes, peppers; nematode resistance in various cereal and other crops, such as banana and potato; frost tolerance in strawberry, *B.t.* clover, trees with reduced lignin, vitamin A rice and bio-pharming with crops and animals for pharmaceuticals.

The third generation technologies are those that are still far from market, but generally require a better understanding of whole gene complexes that control such traits as drought- or salt-tolerance, and nitrogen-fixation. These are likely to bring more explicit consumer benefits than the first generation. These include stress tolerance in cereals, such as thermo, salt- and heavy metal-tolerance; drought resistance; physiological modifications of crops and trees to increase efficiency of resource use (nutrients, water, light) or delaying of ageing in leaves; neutraceuticals (crops boosted with vitamins/minerals); vaccine crops (such as banana and potato); designer crops modified to produce oils or plastics; the development of new markers to replace antibiotics; and legumes with increased tannins for bloat control in cattle.

The first generation technologies have tended only to provide substantial private benefits for the companies producing them and farmers using them. Many of the later generation genetically modified organisms are, by contrast, more multifunctional and public-good oriented, although like all technologies clearly none are without risk. Modifications of crops with low value in rotations, such as legumes and oats, will make them more attractive to farmers because of high protein and energy content. Others will be more efficient in nitrogen use, so reducing nitrate leaching, or modifications of rhizobia could improve the nitrogen-fixing capacity of a wide range of crops. Both options would reduce the need to use nitrogen fertilizers.

Although the pace of change in the development of GM has provoked many debates, there has been relatively little said about the potential benefits for developing countries. Many concerns are about important indirect effects, such as the growing centralization of world agriculture. These represent structural changes in agriculture in which GM crops are a contributor to change, but not necessarily the driver. These contested positions raise important questions. Will GM crops contribute to the further promotion of technological approaches to agricultural development? Could such technologies bring environmental benefits, and so promote sustainability? Are GM technologies essential for feeding a hungry world, or is hunger more a result of poverty, with poor consumers and farmers unable to afford modern, expensive technologies?

Some say emphatically yes, often raising the spectre of famine and excessive population growth as a way to gain greater support for GM as a whole. But GM crops can only help to feed the world if attention is paid to the processes of technology development, to benefit-sharing, and to low-cost methods of production. Most commentators agree that food production will have to increase, and that this will have to come from existing farmland. But past approaches to modern agricultural development have not been successful in all parts of the world.

In most contexts, people are hungry because they are poor. They simply do not have the money to buy either the food they need or the modern technologies that could increase their yields. What they need are readily available and cheap means to improve their farm productivity. So a cereal crop engineered to have bacteria on the roots to fix free nitrogen from the air, or another with the apomixis trait, would be a great benefit for poor farmers. But unless such technologies are cheap, they are unlikely to be accessible to the very people who need them most.

As indicated earlier, agroecological approaches and agricultural sustainability are now an increasingly viable option for many farmers in developing and industrialized countries alike. But where there are no alternatives to specific problems, then GM could bring forth novel and effective options. If research is conducted by public-interest bodies, such as universities, non-government organizations and governments themselves, whose concern is to produce public goods, then biotechnology could result in the spread of technologies that have immense benefits.

Genetically modified organisms are not a single, homogeneous technology. Each application brings different potential benefits and risks for different stakeholders. Regulators, therefore, face special challenges in the face of rapidly developing technical applications. To date, the general approach to risk assessment in agriculture as a whole has been to establish rigorous procedures prior to release, but then to assume that farmers engage in 'good agricultural practice'. The novel nature of emerging policies centres on a fundamental shift in risk assessment to a need to understand the effects of technologies in the field and on the farm. Much of the harm to the environment arises when technologies, whether pesticides, fertilizers or machinery, are not used in accordance with regulators' criteria. The assessment of GMs will, however, now contain new requirements to assess the effects in the context of diverse farm practices, and how this interaction will affect desirable environmental outcomes, such as the integrity of local biodiversity. Such new risk assessments could have a positive side effect by increasing our understanding of agricultural–environment interactions in agricultural systems at large.

There are many types of application of biotechnology, and likely to be several distinct generations of released technologies. It would be wrong, therefore, to generalize about genetic modification – each application needs to be addressed on a case-by-case basis. We need to ask questions about who produces each technology and why; whether it can benefit the poorest, and if so how will they access it; and whether it will have adverse or positive environmental and health side effects. It is likely that biotechnology will make some contributions to agricultural sustainability, but developing the research systems, institutions and policies to make them pro-poor will be more difficult.

Policy Challenges

What we do not yet know is whether a transition to sustainable agriculture will result in enough food to meet the current food needs in developing and industrialized countries, let alone the future needs after continued population growth and the adoption of more urban and meat-rich diets. But what we are seeing is highly promising. There is also scope for additional confidence, as evidence indicates that productivity can grow over time if natural, social and human assets are accumulated.

Sustainable agriculture systems appear to become more productive when human capacity increases, particularly in the form of farmers' capacity to innovate and adapt their farm systems for sustainable outcomes. Sustainable agriculture is not a concretely defined set of technologies, nor is it a simple model or package to be widely applied or fixed with time. It needs to be conceived of as a process for social learning. Lack of information on agroecology and necessary skills to manage complex farms is a major barrier to the adoption of sustainable agriculture.

A problem is that we know much less about these resource-conserving technologies than we do about the use of external inputs in modernized systems. So it is clear that the process by which farmers learn about technology alternatives is crucial. If they are enforced or coerced, then they may only be adopted for a limited period. But if the process is participatory and enhances farmers' ecological literacy of their farms and resources, then the foundation for redesign and continuous innovation is laid.

The idea of agricultural sustainability, therefore, raises important policy questions. In particular, should farmers receive public support for the public benefits they produce in addition to food? Should those that pollute have to pay for restoring the environment and human health? These two principles are called 'the provider gets' and 'the polluter pays', and they are important to both industrialized and developing countries. Three categories of policy instruments are available: advisory and institutional measures, regulatory and legal measures and economic instruments. In practice, effective pollution control and supply of desired public goods requires a mix of all three approaches, together with integration across sectors (MEA, 2005).

Advisory and institutional measures have long formed the backbone of policies to internalize costs and so prevent agricultural pollution. These rely on the voluntary actions of farmers, and are favoured by policy makers because they are cheap and adaptable. Advice is commonly given in the form of codes of good agricultural practice, such as recommended rates of application of pesticides and fertilizer, or measures for soil erosion control. Most governments still employ extension agents to work with farmers on technology development and transfer. A variety of institutional mechanisms can also help to increase social capital and the uptake of more sustainable practices, including encouraging farmers to work together in study groups, investing in extension and advisory services to encourage greater interaction between farmers and extensionists, and encouraging new partnerships between farmers and other rural stakeholders, as regular exchanges and reciprocity increase trust and confidence, and lubricate cooperation.

Regulatory and legal measures are also used to internalize external costs. This can be done either by setting emissions standards for the discharge of a pollutant, or by establishing quality standards for the environment receiving the pollutant. Polluters who exceed standards are then subject to penalties. There are many types of standards, such as operating standards to protect workers, production standards to limit levels of contaminants of residues in foods, emissions standards to limit releases or discharges, such as silage effluents, and environmental quality standards for undesirable pollutants in vulnerable environments, such as pesticides in water. But the problem with such regulations is that most agricultural pollutants are diffuse, or non-point, in nature. It is impossible for inspectors to ensure compliance on hundreds of thousands of farms in the way that they can with a small number of factories. Regulations are also used to eliminate certain practices, and include bans on spraying of pesticides close to rivers and on straw-burning in the UK, and the mandatory requirement to complete full nutrient accounts for farms, such as in the Netherlands and Switzerland. A final use for regulations is the designation and legal protection of certain habitats and species, which are set at national or international levels.

Economic instruments can be used either to ensure that the polluter bears the costs of the pollution damage and the abatement costs incurred in controlling the pollution. They can also be used to reward good behaviour. A variety of economic instruments are available for achieving internalization, including environmental taxes and charges, tradable permits and the targeted use of public subsidies and incentives. Environmental taxes seek to shift the burden of taxation away from economic 'goods', such as labour, towards environmental 'bads', such as waste and pollution. Clearly the market prices for agricultural inputs do not currently reflect the full costs of their use. Environmental taxes or pollution payments, however, seek to internalize some of these costs, so encouraging individuals and businesses to use them more efficiently. Such taxes offer the opportunity of a 'double dividend' by cutting environmental damage, particularly from non-point sources of pollution, whilst promoting welfare. However, many opponents still believe that environmental taxes stifle economic growth.

There are now a wide range of environmental taxes used by countries in Europe and North America. These include carbon and energy taxes in Belgium, Denmark and Sweden; chlorofluorocarbon taxes in Denmark and the US; sulphur taxes in Denmark, France, Finland and Sweden; nitrogen oxide charges in France and Sweden; leaded and unleaded petrol differentials in all EU countries; landfill taxes in Denmark, the Netherlands and the UK; groundwater extraction charges in the Netherlands; and sewage charges in Spain and Sweden. However, environmental taxes have rarely been applied to agriculture, with the notable exception of pesticide taxes in Denmark, Finland, Sweden and in several states of the US; fertilizer taxes in Austria, Finland, Sweden and again several states of the US; and manure charges in Belgium and the Netherlands (Ekins, 1999).

The alternative to penalizing farmers through taxation is to encourage them to adopt non-polluting technologies and practices. This can be done by offering direct subsidies for adoption of sustainable technologies, and by removing perverse subsidies that currently encourage polluting activities. An important policy principle suggests that it is more efficient to promote practices that do not damage the environment rather than to spend on cleaning up after a problem has been created. Many governments provide some direct or indirect public support to their domestic agricultural and rural sectors. Increasingly, payments are being shifted away from being production linked, such as through price support or direct payments, to being retargeted to support sustainable practices. Generally, though, only small amounts of total budgets have been put aside for environmental improvements through such policies as the US Conservation Reserve Programme, the EU's agri-environmental and rural development programmes, and the Australian Landcare programme. Many now believe that all public support for farming should be entirely linked to the provision of public environmental and social goods and services.

The substantial external costs of modern agriculture, and the known external benefits of sustainable agricultural systems, pose great challenges for policy makers. A range of policy reforms could do much to internalize some of these costs and benefits in prices. In practice, as no single solution is likely to suffice, the key issue rests on how policy makers choose an appropriate mix of solutions, how these are integrated, and how farmers, consumers and other stakeholders are involved in the process of reform itself. Attention will therefore need to be paid to the social and institutional processes that both encourage farmers to work and learn together, and result in integrated cross-sectoral partnerships. Policy integration is vital, yet most policies seeking to link agriculture with more environmentally-sensitive management are still highly fragmented.

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Editorial Introduction to Volume I

Jules Pretty

Agricultural Modernization and Interactions with Nature

Agriculture has had many 'revolutions' throughout history, from its advent some 8–10,000 years ago to the renowned 17th–19th-century agricultural revolution in Europe. In the past century, rural environments in most parts of the world have also undergone massive transformations. In some senses, these have been the most extraordinary in their speed of spread of new technologies and the far-reaching nature of their impacts upon social, economic and ecological systems.

Two guiding themes have dominated this period of agricultural and rural development. One has been the need for increased food production to meet the needs of growing populations. Governments have intervened to transform traditional agricultural systems by encouraging the adoption of modern varieties of crops and modern breeds of livestock, together with associated packages of external inputs (such as fertilizers, pesticides, antibiotics, credit, machinery) necessary to make these productive. In addition, they have supported new infrastructure, such as irrigation schemes, roads and markets, guaranteed prices and markets for agricultural produce, as well as a range of other policies. The other theme has been the desire to prevent the degradation of natural resources, perceived to be largely caused by growing populations and their bad practices. To conserve natural resources, governments have encouraged the adoption of soil and water conservation measures to control soil erosion. They have established grazing management schemes to control rangeland degradation. They have excluded people from forests and other sites of high biodiversity to protect wildlife and plants.

According to just these two themes, it would appear that agricultural and rural development has been remarkably successful. Both food production and the amount of land conserved have increased dramatically. Although often seen as mutually exclusive, both have been achieved with largely the same process of modernization. The approach is firmly rooted in and driven by the enlightenment tradition of positivist science (Harvey, 1989; Kurokawa, 1991). External actors identify the problem that needs solving, in these cases too little food or too much degradation. Their concern is to intervene so as to encourage rural people to change their practices. Rational solutions are proposed, and technologies developed. These technologies, known to work in a research station or other controlled environments, are assumed to work elsewhere. They are then passed to the mass of rural people and farmers, and the benefits awaited.

It was Cartesian reductionism and the enlightenment that set the scene for this approach, largely casting aside the assumed folklore and superstitions of age-old thinking. A revolution in science occurred in the late 16th and 17th centuries, largely due to the observations, theories and experiments of Bacon, Galileo, Descartes and Newton, which brought forth mechanistic reductionism, experimental inquiry and positivist science. These methods brought great progress, and continue to be enormously important. But one unfortunate side effect has been an enduring separation of humans from the rest of nature. In the 19th and 20th centuries, wilderness writers, landscape painters, ecologists and farmers sought to reverse, or at least temper, the dominance of this new thinking. It is, though, in the indigenous groups of the world that we find surviving examples of close nature–people connectivity. One of the most comprehensive collections on the diversity of human cultures and their connectedness with nature and the land is Darrell Posey's *Cultural and Spiritual Values of Biodiversity* (1999). Containing contributions from nearly three hundred authors from across the world, these highlight 'the central importance of cultural and spiritual values in an appreciation and preservation of all life'. These voices of the earth demonstrate the widespread intimate connectivity that people have with nature, whether as hunter-gatherers or agriculturalists.

Johan Mathis Turi of the Saami reflects on the mutual shaping in the Norwegian arctic: 'The reindeer is the centre of nature as a whole and I feel I hunt whatever nature gives. Our lives have remained around the reindeer and this is how we have managed the new times so well. It is difficult for me to pick out specific details or particular incidences as explanations for what has happened because my daily life, my nature, is so comprehensive. It includes everything. We say "lotwantua", which means everything is included.' A similar perspective is put by Gamaillie Kilukishah, an Inuit from northern Canada who in translation by Meeka Mike says, 'You must be in constant contact with the land and the animals and the plants... When Gamaillie was growing up, he was taught to respect animals in such a way as to survive from them. At the same time, he was taught to treat them as kindly as you would another fellow person.'

Pera of the Bakalaharil tribe in Botswana points to their attitudes in using and sustaining wild resources: 'Some of our food is from the wild – like fruits and some of our meat... We are happy to conserve, but some conservationists come and say that preservation means that we cannot use the animals at all. To us, preservation means to use, but with love, so that you can use again tomorrow and the following year.' Says Cristina Gualinga of the Quicha, 'Nature, what you call biodiversity, is the primary thing that is in the jungle, in the river, everywhere. It is part of human life. Nature helps us to be free, but if we trouble it, nature becomes angry. All living things are equal parts of nature and we have to care for each other.' Finally, in

Australia, Henrietta Fourmile of the Polidingi Tribe says: 'Not only is it the land and soil that forms our connections with the earth but also our entire life-cycle touches most of our surroundings. The fact that our people hunt and gather these particular species on the land means emphasis is placed on maintaining their presence in the future... What is sometimes called "wildlife" in Australia isn't wild; rather it's something that we have always maintained' (all quotes in Posey, 1999).

Part 1: Before Agriculture

For almost all of human history, people have been hunter-gatherers. If, as seems likely, hominids emerged around 6 million years ago, then some 300,000 generations passed before agriculture was invented, since when some 500–600 generations passed until the emergence of the industrialized era. We must have been good at hunting and gathering, otherwise hominids would never have made it to the present day. Yet in recent times, hunter-gatherer societies have been characterized as backward, uncivilized and unable to enter the modern world. After Darwin, the concept of evolution as a linear and progressive force became widely adopted, and remains with us today. Jean Lamarck erroneously believed in the inheritance of acquired characteristics, and he suggested that species strove to evolve greater complexity, and thus the pinnacle of evolution had to be humans.

Later, Social Darwinism came to suggest that nature was more important than nurture, and that the development of individuals from birth to death (ontogeny) reflected closely the evolutionary development of species (phylogeny). Such ideas of progression (implying that the later is better, and the more complex the cleverer), were subsequently applied to human societies. Lewis Henry Morgan's *Ancient Society*, published in 1877, suggested seven stages of human cultural evolution, beginning with lower savagery and progressing through barbarism eventually to reach civilization. The idea was that all human societies did share a common ancestor, but that some groups (or races) were now higher on the ladder than others. Such ideas fitted very well with prevailing views about the superiority of European and North American culture, and again came to be widely accepted (though of course still hotly contested by many). It was not until the later 20th century that new perspectives began to emerge.

Richard Lee was one of the pioneers of the later 20th century who clearly demonstrated the efficiencies and effectiveness of hunter-gatherer lifestyles. This first paper is drawn from the classic *Man the Hunter* (1968), and shows how hunter-gatherers do not have a precarious existence in which they struggle to survive – the view that had become common. The hunter-gatherer resource base is 'at least routine and reliable and at best surprisingly abundant'. The chapter draws particularly on evidence from the !Kung Bushmen of the Kalahari Desert, and illustrates in detail the wide range of food resources used by local people in this extremely challenging environment. A key finding (again, counter-intuitive to many at the time) was that hunter-gatherers have plenty of time for leisure, often working fewer hours than agriculturalists, and the caloric returns of their activities are good.

Richard Lee and Richard Daly's later *Cambridge Encyclopedia of Hunters and Gatherers* (1999) is an important and comprehensive volume containing case studies of more than 50 of the world's remaining hunter and gatherer peoples. These tell a story of resilience in the face of change, and of the many ways they are affected by modern problems. Thematic essays discuss prehistory, social life, gender, music and art, food and health, religion and indigenous knowledge. In their introductory essay, Lee and Daly make the point that the world's hunter-gatherer peoples – the Arctic Inuit, Aboriginal Australians, Kalahari San and other similar groups – represent the oldest and perhaps most successful human adaptation. Until 12,000 years ago, virtually all humanity lived as hunters and gatherers. Yet in recent centuries they have suffered the ill-effects of modernity. However, fascination with hunting peoples and their ways of life still remains strong. Hunters and gatherers stand at the opposite pole from the dense urban life now experienced by a large proportion of humanity. Yet these same hunters may hold the key to many contemporary concerns – about diet, politics, communities, physical activity and relations with nature. A late Australian Aboriginal writer is quoted here, 'modern ecology can learn a great deal from a people who managed and maintained their world so well for 50,000 years'.

The third paper in this section is from Hugh Brodie's *The Other Side of Eden* (2000). His fieldwork experience is mainly from the polar and boreal north, and he weaves the experiences of native hunter-gatherers into a narrative that reveals a paradox: agriculture is a settled activity, yet has been fundamentally expansionist; whereas hunter-gathering is a mobile activity, cultures and communities self-regulate and stay in the same areas over thousands of years. This points to a problem – current narratives often describe hunter-gatherers as the backward and irresponsible peoples, yet left alone they do not seek to impinge on others. This chapter, entitled *Mind*, explores some of the differences between communities, and shows how change has often been destructive to whole hunter-gatherer peoples. Says Mary Adele, an Innu of Labrador, 'on the land, we are ourselves. In the settlements we are lost.That was why they made our minds weak'. Some believe that hunter-gatherers will inevitably become extinct; others that they represent ways of living that are instructive. Says Brodie, 'without hunter-gatherers, humanity is diminished and cursed; with them, we can achieve a more complete version of ourselves'.

The fourth chapter of this opening section focuses on the Innu of northern Labrador, and analyses the environmental and health benefits of hunting lifestyles and diets. They have undergone profound transitions in recent decades with important implications for conservation, food and health policy. The change from permanent nomadic hunting, gathering and trapping in the country (*nutshimit*) to sedentary village life (known as 'sedentarization') has been associated with a marked decline in physical and mental health. The overarching response of the national government has been to emphasize village-based and institutional solutions. Samson and Pretty show that changing the balance back to country-based activities would address both the primary causes of the crisis and improve the health and well-being of the Innu. Drawing on ethnographic fieldwork, interviews with Innu older people (*Tshenut*), empirical data on nutrition and activity, and comparative data from the experiences of other indigenous peoples, they identify biological and environmental transitions of significance to the current plight of the Innu.

They also show that nutrition and physical activity transitions have had major negative impacts on individual and community health. However, hunting and its associated social and cultural forms is still a viable option as part of a mixed livelihood and economy in the environmentally significant boreal forests and tundra of northern Labrador. Cultural continuity through Innu hunting activities is a means to decelerate, and possibly reverse, their decline. Finally, four new policy areas to help restore country-based activities are suggested: (i) a food policy for country food; (ii) an outpost programme; (iii) ecotourism; and (iv) an amended school calendar.

In the final paper of this section, Luisa Maffi analyses the concept of biocultural diversity and how it relates to current concerns about both ecological and cultural sustainability. Biocultural diversity draws on anthropological, ethnobiological and ethnoecological insights about the relationships between human language, knowledge and practices with the environment. Evidence now indicates that the idea of the existence of pristine environments unaffected by humans is erroneous. Humans have maintained, enhanced and even created biodiversity through culturally diverse practices over many thousands of generations. There are some suggestions that biodiversity and cultural diversity in the form of linguistic differences are associated, though at the local level these relationships do not always stand up to scrutiny. But the role of language is nonetheless critical as a vehicle for communicating and transmitting cultural values, traditional knowledges and practices, and thus for mediating human–environment interactions.

Landscapes can be networks of knowledge and wisdom, conveyed by the language of local people. But the problem is that many languages are under threat. There are some 5000–7000 languages spoken today, of which 32 per cent are in Asia, 30 per cent in Africa, 19 per cent in the Pacific, 15 per cent in the Americas, and 3 per cent in Europe. Yet only half of these languages are each spoken by more than 10,000 speakers. Some 90 per cent of all the world's languages may disappear in the course of this century – yet these very languages are tied to the creation, transmission and perpetuation of local knowledge and cultural behaviour. As language disappears, so does people's ability to understand and talk about their worlds. Natural and cultural continuity are thus connected. The phenomenon of loss has been called the extinction of experience – and the loss of traditional languages and cultures may be hastened by environmental degradation.

Yet in many parts of the world, both in developing and industrialized countries, such traditional ecological knowledge is declining and under threat of extinction. As humans coevolved with their local environments, and have now come to be disconnected, so knowledges that coded stories, binding people to place, have become less valued. New efforts to analyse biocultural diversity on a country-by-country basis are reviewed, and despite some important progress in the international sphere, such as in the Convention on Biodiversity, the most fundamental changes must come from ground-up actions.

Part 2: Early Agriculture

Some 10,000 years ago, hunter-gatherers in various parts of the world began to domesticate some wild plants and animals. These evolved over thousands of seasons under the guidance of people, producing domesticated forms strikingly different from their wild progenitors. Now, wheat, rice, maize, sorghum, barley, potato, cassava, taro, yam, sweet potato and grain legumes are the main sources of human nutrition for billions of people. Plant geneticist, Jack Harlan, reflects on these processes that generated huge reserves of genetic diversity, pointing to the importance of the intimate knowledge of crops by so-called primitive agricultural societies. Centres of diversity are found on every continent (except Australia, where native people did not widely domesticate plants). These centres are characterized by ancient agriculture, great ecological diversity and great human diversity. Such centres were first recognized and described by the Russian agronomist N I Vavilov. This paper goes on to describe contemporary efforts to protect crop genetic diversity in the face of modernizing tendencies to simplify agriculture.

All agricultural systems need water. A few can rely only on rainfall, but most require some kind of system to manage the collection and delivery of water to crops and livestock. Karl Wittfogel's classic *Oriental Despotism* explored the characteristics of hydraulic economies: they involve a division of labour; they intensify cultivation; and they necessitate cooperation on a large scale. All three contribute to the requirement for a particular type of management of both inputs, including water, and outputs of food to markets and consumers. Water necessitates control, and some of this has to be very large-scale, both for flood protection (such as in Egypt or Mesopotamia) and for irrigation management (such as for the rice terrace cultures of Asia). Cooperation is also essential, as water can be captured by the more powerful, and tail-enders in irrigation systems can easily go without. Wittfogel's contribution is to show how such cooperation easily slips into coercion, with punishment for transgression never really absent. Agrohydraulic societies also require active timekeeping and calendar-making and close observation of weather, seasonal patterns and astronomy, as well as the capacity to build canals, dams, roads and other monuments.

Marcus Porcius Cato lived 234–149 BC, and was known as the Orator, the Censor or Cato Major. He was born at Tusculum, some 15km from Rome. His youth was spent on his father's farm, and a love for the soil remained with him though life. He entered the military aged 17 and served in the Second Punic War. Political offices came later, including the consulship in 195 and the censorship in

184 BC. He was always the champion of the common people. Quintilian speaks of Cato's great versatility as a general, philosopher, orator, historian and expert on agriculture. *De Agri Cultura* resembles a farmer's notebook, and constitutes the earliest surviving specimen of connected prose. Although haphazard in style, it contains many long-standing truths, including on the first page, 'And when they would praise a worthy man, their praise took this form: good husbandman, good farmer; one so praised was thought to have received the greatest commendation'.

Marcus Terentius Varro was born more than 30 years after Cato's death, and lived 116–27 BC. He was born in Reate, where Cato's father had his farm, and devoted his life to literature and the antiquities. Under the political banner of Pompey, he held the offices of tribune, aedile and praetor. He came into conflict with Caesar for twice supporting Pompey, was later forgiven and then commanded by Caesar to supervise the great library. Varro claimed by his 78th year to have written several hundred books, but only six survive. The *Res Rusticae* was begun in Varro's 80th year, and it contains perhaps the earliest suggestion of the importance of sustainability in farming. Identified first by Gordon Conway, a section in Varro's third book states that 'agriculture is not only an art, but an important and noble art. It is, as well, a science, which teaches what crops are planted in each kind of soil … in order that the land may regularly produce the largest crops (quo terra maximos perpetuo reddat fructus)'.

Li Wenhua provides an historical review of the emergence of agroecological farming systems in China. As he says, 'for thousands of years, Chinese philosophers have pondered on the harmonious relationship between humans, nature and the environment'. As a result, many effective technologies and practices have been developed (and also forgotten), some of which are now being championed today. It is in China that there is the greatest and most continuous record of agriculture's development. He dates the earliest records of integrated crop, tree, livestock and fish farming to the Shang-West Zhou Dynasties of 1600–800 BC. Later Mensius said in 400 BC, 'if a family owns a certain piece of land with mulberry trees around it, a house for breeding silkworms, domesticated animals raised in its yard for meat, and crop fields cultivated and managed properly for cereals, it will be prosperous and will not suffer starvation'. In one of the earliest recognitions of the need for the sustainable use of natural resources, he also said, 'if the forests are timely felled, then an abundant supply of timber and firewood is ensured, if the fishing net with relatively big holes is timely cast into the pond, then there will be no shortage of fish and turtle for use'.

Still later, other treatises such as the collectively written *Li Shi Chun Qiu* (239 BC) and the *Qi Min Yao Shu* by Jia Sixia (600 AD) celebrated the fundamental value of agriculture to communities and economies, and documented the best approaches for sustaining food production without damage to the environment. These included rotation methods and green manures for soil fertility, the rules and norms for collective management of resources, the raising of fish in rice fields, and the use of manures. Li Wenhua indicates that, 'these present a picture of a prosperous, diversified rural economy and a vivid sketch of pastoral peace'. The chapter goes on to describe the emergence of modern integrated farming systems, including the innovative eco-county programme promoted by the Chinese government from 1994 onwards. Ecological agriculture, with a long history of development in ancient China, is now being 'enriched and upgraded with the progress of modern science and technology, and has gradually become a real approach for sustainable agriculture'.

In 1911, F H King's *Farmers of Forty Centuries* was first published, showing for the first time to the Western world many of the details of agricultural practices and customs of China, Korea and Japan. At that time, the US was 'as yet a nation of but few people widely scattered over a broad land', and yet the ancient cultures of the Far East had been intensively farming for several thousand years on the same land. Here, then, is an early indication of the importance and relevance of sustainability, not that King used this term. Sustainability at least implies being able to do the same thing over long periods of time without causing harm to the environment, and King in his travels came to realize this was precisely what farmers in these three countries had been doing for at least 40 centuries. Many factors were important, including careful selection of crops and livestock breeds, water management and soil fertility maintenance. Manures from both animals and humans were widely used, soil amendments of canal mud regularly dredged and applied to fields, and nitrogen-fixing legumes were widespread in a variety of rotation patterns. King indicates, 'almost every foot of land is made to contribute material for food, fuel or fabric'.

Part 3: Agricultural Revolutions and Change

The landscape itself is a type of common property. It can be enjoyed and appreciated by many if, of course, they are allowed to access it. The idea of commons implies jointness, something people can enjoy either collectively or individually and from which they derive value. Over the centuries, two types of common management emerged in Europe. These were for the common or open-field system of cropland, which persisted for a thousand years, and the common management of wild resources, woodlands, pastures, wastes, rivers and coasts. In these systems, local people held rights for grazing, cutting peat for fuel (turbaries), cutting timber for housing (estovers), grazing acorns and beech mast (pannage), and fishing (piscary).

Over the years, though, both types of common came to be steadily enclosed and privatized, mostly as a result of the actions of landowners and the state driven by the prevailing view that commons were inefficient. The result was an extraordinary transformation of the landscape, particularly in the 18th and early 19th centuries. In the UK, local enclosure had been occurring up to the 17th century, but the process accelerated with the introduction of parliamentary inclosure acts, dating from the early 18th century and continuing through 2750 Acts to 1845, the date of the last general Inclosure Act. At the same time, wastes, heaths, moors and commons were enclosed through 1800 Acts between 1760 and the 1840s. Commissioners with extensive powers were appointed to redesign the landscape in more than 3000 parishes. As a result, 2.75 million hectares of common land were enclosed, comprising 1.82 million hectares of open-field arable, and 0.93 million hectares of so-called wastes. To put this in perspective, there are about 18 million hectares of agricultural land in the UK, of which just 4 million are currently under arable farming, and about half a million still under common land.

In the first paper of this section, Michael Turner and colleagues analyse open-field agriculture of 17th and 18th century England, and show how collective community action had developed to protect scarce resources, and how pressure upon these resources through changing economic and demographic conditions inspired communities to develop and promote sustainable methods of husbandry and management. They show how ecological integrity and equitable ownership in decision making went hand-in-hand. This is in stark contrast to the dominant narrative of the time – that the commons were inefficient and backward.

The next paper describes the elements of the agricultural change in 17th–18th-century Europe in what has generally come to be called *The* Agricultural Revolution. During a period where there was no government ministry of agriculture, no national agricultural research or extension agencies, no radio or TV, no pesticides or inorganic fertilizers, and poor rural transport infrastructure, aggregate cereal and livestock production increased to unprecedented levels. In the 150 years after 1700, wheat production in Britain increase four-fold, and barley and oats three-fold; the number of cattle supplied to markets tripled and sheep doubled. Two components were vital: a wide range of innovative technologies were developed by farmers, and then these were spread to other farmers through tours, farmer groups, open days and publications, and then adapted to local conditions by rigorous experimentation. New crops offered diversification opportunities to farmers by allowing intensification of land use. Increased fodder supply meant more livestock, and so increased the supply of manure to improve soil fertility. Selective breeding of livestock produced more efficient conversion of feed to meat, so permitting slaughter at an earlier age and higher stocking rates. New labour-saving machinery released farmers from labour-bottlenecks at cereal and hay harvests, and new tools and techniques improved the efficiency of seed saving. Farmers widely experimented with livestock breeding, irrigation, drainage, handtools and pest control.

The Green Revolution of the latter half of the 20th century was another significant agricultural revolution. Without it, poverty and hunger would be much more widespread, especially as it coincided with a period of rapid worldwide population growth. In this chapter, drawn from Gordon Conway's *Doubly Green Revolution*, the factors of success of the green revolution are discussed and analysed. Fundamental to success was the application of modern science and technology to the task of getting crops to yield more. The success of the green revolution lay in its simplicity. Agricultural scientists bred new varieties of staple cereals that matured quickly, so permitting two or three crops to be grown each year; that were day-length insensitive, so could be extended to farmers at a wide range of latitudes; and that were producers of more grain at the expense of straw. They were also much more nitrogen-responsive than traditional varieties. These modern varieties were distributed to farmers together with inputs, including inorganic fertilizers, pesticides, machinery, credit and water regulation. These technical innovations were then implemented in the best favoured agroclimatic regions and for those classes of farmers with the best expectations of and means for realizing the potential yield increases.

Conway draws attention to the limitations of the green revolution – its impact on the poor has been less than expected, it has not reduced natural resource degradation, its geographic impact has been localized, and there are signs of diminishing returns. In particular, the green revolution missed many agricultural systems which, until recently, represent a largely forgotten agriculture. These tend to be located in the drylands, wetlands, uplands, savannas, swamps, near-deserts, mountains and hills, and forests. Farming systems in these areas are complex and diverse, agricultural yields are low, and rural livelihoods are often dependent on wild resources as well as agricultural produce. They are remote from markets and infrastructure; they are located on fragile or problem soils; and less likely to be visited by agricultural scientists and extension workers or studied in research institutions. The poorest countries tend to have higher proportions of these agricultural systems.

James Scott's book *Seeing Like a State* deploys the Greek term *mētis* to describe 'forms of knowledge embedded in local experience'. Mētis is normally translated as meaning 'cunning' or 'cunning intelligence', but Scott says this fails to do justice to a range of practical skills and acquired intelligence represented by the term. He contrasts such mētis with the 'more general, abstract knowledge displayed by the state and its technical agencies' by describing villagization in Tanzania and Ethiopia, Soviet collectivization, the emergence of high-modernist cities and the widespread standardization of agriculture. Failures come when mētis is designed out, as the state rarely makes the kinds of necessary daily adjustments required for the effective working of systems. Mētis, he says, is 'plastic, local and divergent... It is in fact the idiosyncrasies of mētis, its contextualities, and its fragmentation that make it so permeable, so open to new ideas'.

This particular chapter explores the Soviet collectivization project, and shows how high modernism was implemented by thinking big. Nearly everything was planned on a monumental scale – from cities, buildings, construction projects and collectivization of agriculture through rationalization and industrialization. Many of these ideas were imported from the US by Russian agronomists and engineers in the 1920s and 1930s. Some of the resulting projects were enormous. One Sovkhoz collective farm established 1600km south of Moscow cropped 150,000 hectares of solely wheat culture – and was later found to be an abject failure. The state prosecuted a 'war' against the peasantry in the period of 1930–1934 in order to liquidate the kulaks (peasant farmers) and enforce collectivization. The ensuing famine resulted in a death toll of at least 3–4 million people, and possibly as many as 20 million.

In the final chapter of this section, Pedro Sanchez and colleagues set out the themes and challenges for alternatives to slash-and-burn agriculture. Known also as shifting, swidden, milpa, shamba, jhum and kaingin agriculture, slash-and-burn has long been a sustainable and persistent form of agricultural system in the forests of the tropics and sub-tropics. Trees are cleared, crops grown for 1–2 years, livestock then grazed, and then the community moves to cut another area of the forest. Provided they do not return for 20–30 years to the same plot, then sufficient time elapses for the forest fully to regenerate, and the system can persist over long periods. But when total forest cover declines, through logging, ranching or other development projects, or population increases, then the rotation cycle shortens, and the system cannot retain its fertility and success. In some quarters, small farmers engaged in slash-and-burn are blamed for the destruction of tropical rainforests, but in truth it is other pressures that have made their management systems no longer viable. This chapter documents the recent international efforts to produce effective alternatives to slash and burn for the roughly 40 million people (2 per cent of the world's agricultural population in the tropics) of Latin America, Africa and Asia who currently rely on these systems of management. Lands can be rehabilitated with the right scientific and technological innovations, as well as the appropriate social, economic and policy support.

Part 4: Modern Agricultural Reforms

The knowledge that soil erosion was both costly and damaging was first appreciated on a wide scale by agricultural authorities in the US and colonial Africa and India in the early part of the 20th century. They took the view that farmers were mismanagers of soil and water, and so had to be encouraged to adopt conserving practices. Erosion was considered a technical problem requiring only technical action, and so authorities encouraged farmers to construct terraces, bunds (embankments of soil), ditches and drains, and to adopt alternative cropping patterns and contour planting. They also resettled people to discourage the use of certain lands, and destocked other regions of livestock to reduce grazing pressure.

The first chapter in this section by Pretty and Shah describes how this style of intervention was first established in the US. It emerged followed the period of severe wind erosion and dust storms that came to be known as the Dust Bowl of the early 1930s. Even though there were subsidies to encourage farmers to adopt new measures, authorities were granted wide-ranging powers to enforce land use regulations. This pattern of intervention was then repeated by colonial authorities in Africa and Asia. Early regulations had been adapted to local conditions and were grounded in farming and grazing practice. But later, administrators travelling to the US saw the devastation, and brought back recommendations for large-scale bunding and ridging, combined with contour ploughing and planting. Locally adapted practices were largely ignored, even though they were more effective in droughts. These measures were imposed on farmers, who were then monitored closely to ensure their compliance. In some countries, this meant the compulsory resettlement of many people to new villages.

This has been the style for many soil conservation programmes. Technologies known to work under certain conditions are widely used or recommended, and backed up by local and national policies that give powers to the state to execute specified improvements on farmers' fields and to allocate the costs of these improvements between the farmers and the state. In many places, provisions have been made for compulsory treatment of the fields of farmers refusing land treatment. This has led to increased alienation with, for example, people uprooting plantations and destroying fencing and conservation measures. The quantitative achievements of conventional soil conservation programmes can appear impressive. Throughout the world, terraces have been built, trees planted and farmers trained on a massive scale. Yet these results have often been short-lived, tending to occur only within project boundaries and before project completion. If performance is measured over long periods, the results have been extraordinarily poor for the amount of effort and money expended: technologies have neither persisted nor spread independently into non-project areas.

In the second paper, Erick Fernandes and colleagues summarize the types of transitions effected by the Green Revolution, and then set out a vision for agriculture centred on field-culture, with sensitivities towards patterns in space and time. Monocultures are often erroneously seen as real agriculture, yet it is polycultures that have long offered rural people opportunities to maintain on-farm diversity of products and their functions. Multifunctional systems with many components are more resilient and meet many needs compared with mono-functional systems. This chapter sets out four ideas that need revising: that pest control always needs pesticides, that soil fertility constraints always need chemical fertilizers, that solving water problems needs new irrigation, and that raising productivity only needs genetic and breeding approaches. There are many productive opportunities that can arise by adopting more biological and people-centred approaches to agricultural development and its sustainability.

The third paper is the second of two chapters from Li Wenhua's 2001 book on agroecological farming systems in China. This long chapter contains considerable detail on integrated farming systems at different scales from homestead gardens, eco-villages, eco-counties and forest shelterbelts. All contain many significant innovations of relevance to many systems elsewhere in the world. Most rural families in China have very small amounts of land, on average 0.02ha per household, and so their approaches need to be intensive, make effective use of all resources, and above all produce enough food. Of particular importance are the sections on eco-villages and eco-counties. Both represent geographically integrated efforts of what is called ecological engineering in China.

The benefits of integrated systems for local people and the environment can be substantial – more income from the vegetables, better and more diverse food, reduced costs for fertilizers, reduced workload for women, and better living conditions in the house and kitchen. The Ministry promotes a variety of integrated models across the country, involving mixtures of biogas digesters, fruit and vegetable gardens, underground water tanks, solar greenhouses, solar stoves and heaters, and pigs and poultry. These are fitted to local conditions. Whole integrated systems are now being demonstrated across many regions of China, and altogether 8.5 million households have biogas digesters. The target for the coming decade is the construction of another one million digesters per year. As the systems of waste digestion and energy production are substituting for fuelwood, coal or inefficient crop-residue burning, the benefits for the natural environment are substantial – each digester saves the equivalent of 1.5 tonnes of wood per year, or 3–5mu of forest. Each year, these biogas digesters are effectively preventing 6–7 million tonnes of carbon from being emitted to the atmosphere.

Biotechnology remains a controversial topic in agricultural development. Some believe it represents huge risks to agricultural and natural systems; others indicate that such new technologies are essential for agricultural development. Neither view is entirely correct, as biotechnology, and particularly genetic modification, is not one thing, but a wide variety of technologies that represent different potential benefits and risks. Thus assessment should be on a case-by-case basis so that useful technologies are able to be used by farmers, and potentially harmful ones not approved for cultivation. In this paper, Doreen Mnyulwa and Julius Mugwagwa review agricultural biotechnology and its safety mechanisms across southern Africa. Only in South Africa itself have GM crops been commercially cultivated to date, and these are already proving beneficial to small farmers. Some of these technologies have been developed within South Africa with domestic government support. Yet the murky interface between food aid, international politics, science and regulations remains complex, particularly over the potential 'dumping' of GM food aid to the region.

The final chapter of this volume is drawn from Michael Bell's excellent account of the transformations brought about by the Practical Farmers of Iowa (PFI). Formed to develop and spread new ideas for sustainable farming, this organization is run by farmers for themselves. They saw that big agriculture was no longer the success it made itself out to be, and realized they needed to help themselves by developing new ways of collaborating and generating new effective farming methods. But PFI is about much more than that. Bell begins by recalling a conversation with Dick Thompson, who has more than 20 years of innovation on his farm. Thompson says you should 'get along, but don't go along'. Get along by working with others, emphasizing the importance of communication and dialogue. Don't go along by not just following what others do – then adapt, change, evolve and be in control. This suggests a very different model for post- or non-modern agriculture. Not the land of monocultures and monologues, of simple diffusion of ideas and adoption of without thinking. Here is an approach to cultivation that embraces the creativity of difference and openness, a project that will never be finished. As Bell says, 'let us put the culture back in agriculture of all farms and all places'.

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Part I

Before Agriculture

1

What Hunters Do for a Living, or, How to Make Out on Scarce Resources

Richard B. Lee

The current anthropological view of hunter-gatherer subsistence rests on two questionable assumptions. First is the notion that these peoples are primarily dependent on the hunting of game animals, and second is the assumption that their way of life is generally a precarious and arduous struggle for existence.

Recent data on living hunter-gatherers (Meggitt, 1964b; Service, 1960) show a radically different picture. We have learned that in many societies, plant and marine resources are far more important than are game animals in the diet. More important, it is becoming clear that, with a few conspicuous exceptions, the hunter-gatherer subsistence base is at least routine and reliable and at best surprisingly abundant. Anthropologists have consistently tended to under-estimate the viability of even those 'marginal isolates' of hunting peoples that have been available to ethnographers.

The purpose of this paper is to analyse the food getting activities of one such 'marginal' people, the !Kung Bushmen of the Kalahari Desert. Three related questions are posed: How do the Bushmen make a living? How easy or difficult is it for them to do this? What kinds of evidence are necessary to measure and evaluate the precariousness or security of a way of life? And after the relevant data are presented, two further questions are asked: What makes this security of life possible? To what extent are the Bushmen typical of hunter-gatherers in general?

Bushman Subsistence

The !Kung Bushmen of Botswana are an apt case for analysis.[1] They inhabit the semi-arid north-west region of the Kalahari Desert. With only six to nine inches of

Lee R B. 1968. What hunters do for a living, or, how to make out on scarce resources. In Lee R and Devore E. *Man the Hunter.* Aldine, Chicago, 30–48.

rainfall per year, this is, by any account, a marginal environment for human habitation. In fact, it is precisely the unattractiveness of their homeland that has kept the !Kung isolated from extensive contact with their agricultural and pastoral neighbours.

Fieldwork was carried out in the Dobe area, a line of eight permanent waterholes near the South-West Africa border and 125 miles south of the Okavango River. The population of the Dobe area consists of 466 Bushmen, including 379 permanent residents living in independent camps or associated with Bantu cattle posts, as well as 87 seasonal visitors. The Bushmen share the area with some 340 Bantu pastoralists largely of the Herero and Tswana tribes. The ethnographic present refers to the period of fieldwork: October 1963–January, 1965.

The Bushmen living in independent camps lack firearms, livestock and agriculture. Apart from occasional visits to the Herero for milk, these !Kung are entirely dependent upon hunting and gathering for their subsistence. Politically they are under the nominal authority of the Tswana headman, although they pay no taxes and receive very few government services. European presence amounts to one overnight government patrol every six to eight weeks. Although Dobe-area !Kung have had some contact with outsiders since the 1880s, the majority of them continue to hunt and gather because there is no viable alternative locally available to them.[2]

Each of the 14 independent camps is associated with one of the permanent waterholes. During the dry season (May–October) the entire population is clustered around these wells. Table 1.1 shows the numbers at each well at the end of the 1964 dry season. Two wells had no camp resident and one large well supported five camps. The number of camps at each well and the size of each camp changed frequently during the course of the year. The 'camp' is an open aggregate of cooperating persons which changes in size and composition from day to day. Therefore, I have avoided the term 'band' in describing the !Kung Bushman living groups.[3]

Table 1.1 *Number and distribution of resident Bushmen and Bantu by waterhole*[a]

Name of waterhole	*No. of camps*	*Population of camps*	*Other Bushmen*	*Total Bushmen*	*Bantu*
Dobe	2	37	—	37	—
!angwa	1	16	23	39	84
Bate	2	30	12	42	21
!ubi	1	19	—	19	65
!gose	3	52	9	61	18
/ai/ai	5	94	13	107	67
!xabe	—	—	8	8	12
Mahopa	—	—	23	23	73
Total	14	248	88	336	340

Note: [a] Figures do not include 130 Bushmen outside area on the date of census.

Each waterhole has a hinterland lying within a six-mile radius which is regularly exploited for vegetable and animal foods. These areas are not territories in the zoological sense, since they are not defended against outsiders. Rather they constitute the resources that lie within a convenient walking distance of a waterhole. The camp is a self-sufficient subsistence unit. The members move out each day to hunt and gather, and return in the evening to pool the collected foods in such a way that every person present receives an equitable share. Trade in foodstuffs between camps is minimal; personnel do move freely from camp to camp, however. The net effect is of a population constantly in motion. On the average, an individual spends a third of his time living only with close relatives, a third visiting other camps, and a third entertaining visitors from other camps.

Because of the strong emphasis on sharing, and the frequency of movement, surplus accumulation of storable plant foods and dried meat is kept to a minimum. There is rarely more than two or three days' supply of food on hand in a camp at any time. The result of this lack of surplus is that a constant subsistence effort must be maintained throughout the year. Unlike agriculturalists who work hard during the planting and harvesting seasons and undergo 'seasonal unemployment' for several months, the Bushmen hunter-gatherers collect food every third or fourth day throughout the year.

Vegetable foods comprise from 60–80 per cent of the total diet by weight, and collecting involves two or three days of work per woman per week. The men also collect plants and small animals but their major contribution to the diet is the hunting of medium and large game. The men are conscientious but not particularly successful hunters; although men's and women's work input is roughly equivalent in terms of man-day of effort, the women provide two to three times as much food by weight as the men.

Table 1.2 summarizes the seasonal activity cycle observed among the Dobe-area !Kung in 1964. For the greater part of the year, food is locally abundant and easily collected. It is only during the end of the dry season in September and October, when desirable foods have been eaten out in the immediate vicinity of the waterholes that the people have to plan longer hikes of 10–15 miles and carry their own water to those areas where the mongongo nut is still available. The important point is that food is a constant, but distance required to reach food is a variable; it is short in the summer, fall and early winter, and reaches its maximum in the spring.

This analysis attempts to provide quantitative measures of subsistence status including data on the following topics: abundance and variety of resources, diet selectivity, range size and population density, the composition of the work force, the ratio of work to leisure time, and the caloric and protein levels in the diet. The value of quantitative data is that they can be used comparatively and also may be useful in archaeological reconstruction. In addition, one can avoid the pitfalls of subjective and qualitative impressions; for example, statements about food 'anxiety' have proven to be difficult to generalize across cultures (see Holmberg, 1950; and Needham's critique, 1954).

Table 1.2 *The Bushman annual round*

Season		*Jan.*	*Feb.*	*Mar.*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
			Summer Rains		*Autumn Dry*			*Winter Dry*			*Spring Dry*	*First Rains*	
Availability of water		Temporary summer pools everywhere			Large summer pools			Permanent waterholes only				Summer pools developing	
Group moves		Widely dispersed at summer pools			At large summer pools			All population restricted to permanent waterholes				Moving out to summer pools	
Men's subsistence activities	1.	Hunting with bow, arrows and dogs (Year-round)											
	2.	Running down immatures					Trapping small game in snares					Running down newborn animals	
	3.	Some gathering (Year-round)											
Women's subsistence activities	1.	Gathering of mongongo nuts (Year-round)											
	2.	Fruits, berries, melons					Roots, bulbs, resins				Roots, leafy, greens		
Ritual activities		Dancing, trance performances and ritual curing (Year-round)											
							Boys' initiation[a]						[b]
Relative subsistence hardship		Water-food distance minimal						Increasing distance from water to food				Water-food distance minimal	

[a] Held once every five years; none in 1963–64.
[b] New Year's: Bushmen join the celebrations of their missionized Bantu neighbours.

Abundance and variety of resources

It is impossible to define 'abundance' of resources absolutely. However, one index of *relative* abundance is whether or not a population exhausts all the food available from a given area. By this criterion, the habitat of the Dobe-area Bushmen is abundant in naturally occurring foods. By far the most important food is the Mongongo (mangetti) nut (*Ricinodendron rautanenii* Schinz). Although tens of thousands of pounds of these nuts are harvested and eaten each year, thousands more rot on the ground each year for want of picking.

The mongongo nut, because of its abundance and reliability, alone accounts for 50 per cent of the vegetable diet by weight. In this respect it resembles a cultivated staple crop such as maize or rice. Nutritionally it is even more remarkable, for it contains five times the calories and ten times the proteins per cooked unit of the cereal crops. The average daily per-capita consumption of 300 nuts yields about 1260 calories and 56 grammes (g) of protein. This modest portion, weighing only about 7.5 ounces, contains the caloric equivalent of 2.5 pounds of cooked rice and the protein equivalent of 14 ounces of lean beef (Watt and Merrill, 1963).

Furthermore the mongongo nut is drought resistant and it will still be abundant in the dry years when cultivated crops may fail. The extremely hard outer shell protects the inner kernel from rot and allows the nuts to be harvested for up to 12 months after they have fallen to the ground. A diet based on mongongo nuts is in fact more reliable than one based on cultivated foods, and it is not surprising, therefore, that when a Bushman was asked why he hadn't taken to agriculture he replied: 'Why should we plant, when there are so many mongongo nuts in the world?'

Apart from the mongongo, the Bushmen have available 84 other species of edible food plants, including 29 species of fruits, berries and melons and 30 species of roots and bulbs. The existence of this variety allows for a wide range of alternatives in subsistence strategy. During the summer months the Bushmen have no problem other than to choose among the tastiest and most easily collected foods. Many species, which are quite edible but less attractive, are bypassed, so that gathering never exhausts *all* the available plant foods of an area. During the dry season the diet becomes much more eclectic and the many species of roots, bulbs and edible resins make an important contribution. It is this broad base that provides an essential margin of safety during the end of the dry season when the mongongo nut forests are difficult to reach. In addition, it is likely that these rarely utilized species provide important nutritional and mineral trace elements that may be lacking in the more popular foods.

Diet selectivity

If the Bushmen were living close to the 'starvation' level, then one would expect them to exploit every available source of nutrition. That their life is well above this level is indicated by the data in Table 1.3. Here all the edible plant species are

Table 1.3 *!Kung Bushman plant foods*

Food class	*Part eaten*									*Totals (%)*	
	Fruit and nut	*Bean and root*	*Fruit and stalk*	*Root, bulb*	*Fruit, berry, melon*	*Resin*	*Leaves*	*Seed, bean*	*Total number of species in class*	*Estimated contribution by weight to vegetable diet*	*Estimated contribution of each species*
I. PRIMARY Eaten daily throughout year (mongongo nut)	1	—	—	—	—	—	—	—	1	c. 50	c. 50[a]
II. MAJOR Eaten daily in season	1	1	1	1	4	—	—	—	8	c. 25	c. 3
III. MINOR Eaten several times per week in season	—	—	—	7	3	2	2	—	14	c. 15	c. 1
IV. SUPPLEMENTARY Eaten when classes I–III locally unavailable	—	—	—	9	12	10	1	—	32	c. 7	c. 0.2
V. RARE Eaten several times per year	—	—	—	9	4	—	—	—	13	c. 3	c. 0.1
VI. PROBLEMATIC Edible but not observed to be eaten	—	—	—	4	6	4	1	2	17	nil	nil
Total Species	2	1	1	30	29	16	4	2	85	100	—

[a] 1 species constitutes 50 per cent of the vegetable diet by weight.
[b] 23 species constitutes 90 per cent of the vegetable diet by weight.
[c] 62 species constitutes the remaining 10 per cent of the diet.

arranged in classes according to the frequency with which they were observed to be eaten. It should be noted, that although there are some 85 species available, about 90 per cent of the vegetable diet by weight is drawn from only 23 species. In other words, 75 per cent of the listed species provide only 10 per cent of the food value.

In their meat-eating habits, the Bushmen show a similar selectivity. Of the 223 local species of animals known and named by the Bushmen, 54 species are classified as edible, and of these only 17 species were hunted on a regular basis.[4] Only a handful of the dozens of edible species of small mammals, birds, reptiles and insects that occur locally are regarded as food. Such animals as rodents, snakes, lizards, termites and grasshoppers, which in the literature are included in the Bushman dietary (Schapera, 1930), are despised by the Bushmen of the Dobe area.

Range size and population density

The necessity to travel long distances, the high frequency of moves, and the maintenance of populations at low densities are also features commonly associated with the hunting and gathering way of life. Density estimates for hunters in western North America and Australia have ranged from 3 persons/square mile to as low as 1 person/100 square miles (Kroeber, 1939; Radcliffe-Brown, 1930). In 1963–1965, the resident and visiting Bushmen were observed to utilize an area of about 1000 square miles during the course of the annual round for an effective population density of 41 persons/100 square miles. Within this area, however, the amount of ground covered by members of an individual camp was surprisingly small. A day's round-trip of 12 miles serves to define a 'core' area 6 miles in radius surrounding each water point. By fanning out in all directions from their well, the members of a camp can gain access to the food resources of well over 100 square miles of territory within a two-hour hike. Except for a few weeks each year, areas lying beyond this 6-mile radius are rarely utilized, even though they are no less rich in plants and game than are the core areas.

Although the Bushmen move their camps frequently (five or six times a year) they do not move them very far. A rainy season camp in the nut forests is rarely more than 10 or 12 miles from the home waterhole, and often new campsites are occupied only a few hundred yards away from the previous one. By these criteria, the Bushmen do not lead a free-ranging nomadic way of life. For example, they do not undertake long marches of 30 to 100 miles to get food, since this task can be readily fulfilled within a day's walk of home base. When such long marches do occur they are invariably for visiting, trading and marriage arrangements, and should not be confused with the normal routine of subsistence.

Demographic factors

Another indicator of the harshness of a way of life is the age at which people die. Ever since Hobbes characterized life in the state of nature as 'nasty, brutish and short', the assumption has been that hunting and gathering is so rigorous that members of such societies are rapidly worn out and meet an early death. Silberbauer, for example, says of the Gwi Bushmen of the central Kalahari that 'life expectancy … is difficult to calculate, but I do not believe that many live beyond 45' (1965, p17). And Coon has said of the hunters in general:

> The practice of abandoning the hopelessly ill and aged has been observed in many parts of the world. It is always done by people living in poor environments where it is necessary to move about frequently to obtain food, where food is scarce, and transportation difficult … Among peoples who are forced to live in this way the oldest generation, the generation of individuals who have passed their physical peak is reduced in numbers and influence. There is no body of elders to hand on tradition and control the affairs of younger men and women, and no formal system of age grading (1948, p55).

The !Kung Bushmen of the Dobe area flatly contradict this view. In a total population of 466, no fewer than 46 individuals (17 men and 29 women) were determined to be over 60 years of age, a proportion that compares favourably to the percentage of elderly in industrialized populations.

The aged hold a respected position in Bushman society and are the effective leaders of the camps. Senilicide is extremely rare. Long after their productive years have passed, the old people are fed and cared for by their children and grandchildren. The blind, the senile and the crippled are respected for the special ritual and technical skills they possess. For instance, the four elders at !gose waterhole were totally or partially blind, but this handicap did not prevent their active participation in decision making and ritual curing.

Another significant feature of the composition of the work force is the late assumption of adult responsibility by the adolescents. Young people are not expected to provide food regularly until they are married. Girls typically marry between the ages of 15 and 20, and boys about five years later, so that it is not unusual to find healthy, active teenagers visiting from camp to camp while their older relatives provide food for them.

As a result, the people in the age group 20–60 support a surprisingly large percentage of non-productive young and old people. About 40 per cent of the population in camps contribute little to the food supplies. This allocation of work to young and middle-aged adults allows for a relatively carefree childhood and adolescence and a relatively unstrenuous old age.

Leisure and work

Another important index of ease or difficulty of subsistence is the amount of time devoted to the food quest.[5] Hunting has usually been regarded by social scientists as a way of life in which merely keeping alive is so formidable a task that members of such societies lack the leisure time necessary to 'build culture'.[6] The !Kung Bushmen would appear to conform to the rule, for as Lorna Marshall says:

> It is vividly apparent that among the !Kung Bushmen, ethos, or 'the spirit which actuates manners and customs,' is survival. Their time and energies are almost wholly given to this task, for life in their environment requires that they spend their days mainly in procuring food (1965, p247).

It is certainly true that getting food is the most important single activity in Bushman life. However this statement would apply equally well to small-scale agricultural and pastoral societies too. How much time is *actually* devoted to the food quest is fortunately an empirical question. And an analysis of the work effort of the Dobe Bushmen shows some unexpected results. From 6 July to 2 August 1964, I recorded all the daily activities of the Bushmen living at the Dobe waterhole. Because of the coming and going of visitors, the camp population fluctuated in size day by day, from a low of 23 to a high of 40, with a mean of 31.8 persons. Each day some of the adult members of the camp went out to hunt and/or gather while others stayed home or went visiting. The daily recording of all personnel on hand made it possible to calculate the number of man-days of work as a percentage of total number of man-days of consumption.

Although the Bushmen do not organize their activities on the basis of a seven-day week, I have divided the data this way to make them more intelligible. The work-week was calculated to show how many days out of seven each adult spent in subsistence activities (Table 1.4, Column 7). Week II has been eliminated from the totals since the investigator contributed food. In week I, the people spent an average of 2.3 days in subsistence activities, in week III, 1.9 days, and in week IV, 3.2 days. In all, the adults of the Dobe camp worked about two and a half days a week. Since the average working day was about six hours long, the fact emerges that !Kung Bushmen of Dobe, despite their harsh environment, devote from 12 to 19 hours a week to getting food. Even the hardest working individual in the camp, a man named ≠oma who went out hunting on 16 of the 28 days, spent a maximum of 32 hours a week in the food quest.

Because the Bushmen do not amass a surplus of foods, there are no seasons of exceptionally intensive activities such as planting and harvesting, and no seasons of unemployment. The level of work observed is an accurate reflection of the effort required to meet the immediate caloric needs of the group. This work diary covers the mid-winter dry season, a period when food is neither at its most plentiful nor at its scarcest levels, and the diary documents the transition from better to worse conditions (see Table 1.2). During the fourth week the gatherers were making overnight trips to camps in the mongongo nut forests seven to ten miles distant from the waterhole. These longer trips account for the rise in the level of work, from 12 or 13 to 19 hours per week.

If food getting occupies such a small proportion of a Bushman's waking hours, then how *do* people allocate their time? A woman gathers on one day enough food to feed her family for three days, and spends the rest of her time resting in camp, doing embroidery, visiting other camps or entertaining visitors from other camps. For each day at home, kitchen routines, such as cooking, nut cracking, collecting

Table 1.4 *Summery of Dobe work diary*

Week	*(l) Mean group size*	*(2) Adult-days*	*(3) Child-days*	*(4) Total man-days of consumption*	*(5) Man-days of work*	*(6) Meat (lbs)*	*(7) Average work week/adult*	*(8) Index of subsistence effort*
I (July 6–12)	25.6 (23–29)	114	65	179	37	104	2.3	.21
II (July 13–19)	28.3 (23–27)	125	73	198	22	80	1.2	.11
III (July 20–26)	34.3 (29–40)	156	84	240	42	177	1.9	.18
IV (July 27– Aug. 2)	35.6 (32–40)	167	82	249	77	129	3.2	.31
4-wk. total	30.9	562	304	866	178	490	2.2	.21
Adjusted total[a]	31.8	437	231	668	156	410	2.5	.23

[a] See text

Key: Column 1: Mean group size $= \dfrac{\text{total man-days of consumption}}{7}$.

Column 7: Work week = the number of work days per adult per week.

Column 8: Index of subsistence effort $= \dfrac{\text{man-days of work}}{\text{man-days of consumption}}$ (e.g., in Week I, the value of 'S' = .21, i.e., 21 days of work/100 days of consumption or 1 work day produces food for 5 consumption days).

firewood and fetching water, occupy one to three hours of her time. This rhythm of steady work and steady leisure is maintained throughout the year.

The hunters tend to work more frequently than the women, but their schedule is uneven. It is not unusual for a man to hunt avidly for a week and then do no hunting at all for two or three weeks. Since hunting is an unpredictable business and subject to magical control, hunters sometimes experience a run of bad luck and stop hunting for a month or longer. During these periods, visiting, entertaining and especially dancing are the primary activities of men. (Unlike the Hadza, gambling is only a minor leisure activity.)

The trance-dance is the focus of Bushman ritual life; over 50 per cent of the men have trained as trance-performers and regularly enter trance during the course of the all-night dances. At some camps, trance-dances occur as frequently as two or three times a week and those who have entered trances the night before rarely go out hunting the following day. Accounts of Bushman trance performances have been published in Lorna Marshall (1962) and Lee (1967). In a camp with five or more hunters, there are usually two or three who are actively hunting and several others who are inactive. The net effect is to phase the hunting and non-hunting so that a fairly steady supply of meat is brought into a camp.

Caloric returns

Is the modest work effort of the Bushmen sufficient to provide the calories necessary to maintain the health of the population? Or have the !Kung, in common with some agricultural peoples (see Richards, 1939), adjusted to a permanently substandard nutritional level?

During my fieldwork I did not encounter any cases of kwashiorkor, the most common nutritional disease in the children of African agricultural societies. However, without medical examinations, it is impossible to exclude the possibility that subclinical signs of malnutrition existed.[7]

Another measure of nutritional adequacy is the average consumption of calories and proteins per person per day. The estimate for the Bushmen is based on observations of the weights of foods of known composition that were brought into Dobe camp on each day of the study period. The per-capita figure is obtained by dividing the total weight of foodstuffs by the total number of persons in the camp. These results are set out in detail elsewhere (Lee, in press) and can only be summarized here. During the study period 410 pounds of meat were brought in by the hunters of the Dobe camp, for a daily share of nine ounces of meat per person. About 700 pounds of vegetable foods were gathered and consumed during the same period. Table 1.5 sets out the calories and proteins available per capita in the !Kung Bushman dietary from meat, mongongo nuts and other vegetable sources.

This output of 2140 calories and 93.1 grams of protein per person per day may be compared with the Recommended Daily Allowances (RDA) for persons of the small size and stature but vigorous activity regime of the !Kung Bushmen. The RDA for Bushmen can be estimated at 1975 calories and 60 grams of protein per

Table 1.5 *Caloric and protein levels in the !Kung Bushman dietary, July–August 1964*

Class of food	Percentage contribution to diet by weight	Per capita consumption			Percentage caloric contribution of meat and vegetables
		Weight in grams	Protein in grams	Calories per person per day	
Meat	37	230	34.5	690	33
Mongongo nuts	33	210	56.7	1260	67
Other vegetable foods	30	190	1.9	190	
Total All sources	100	630	93.1	2140	100

person per day. (Taylor and Pye, 1966, pp45–48, 463). Thus it is apparent that food output exceeds energy requirements by 165 calories and 33 grams of protein. One can tentatively conclude that even a modest subsistence effort of two or three days work per week is enough to provide an adequate diet for the !Kung Bushmen.

The Security of Bushman Life

I have attempted to evaluate the subsistence base of one contemporary hunter-gatherer society living in a marginal environment. The !Kung Bushmen have available to them some relatively abundant high-quality foods, and they do not have to walk very far or work very hard to get them. Furthermore this modest work effort provides sufficient calories to support not only the active adults, but also a large number of middle-aged and elderly people. The Bushmen do not have to press their youngsters into the service of the food quest, nor do they have to dispose of the oldsters after they have ceased to be productive.

The evidence presented assumes an added significance because this security of life was observed during the third year of one of the most severe droughts in South Africa's history. Most of the 576,000 people of Botswana are pastoralists and agriculturalists. After the crops had failed three years in succession and over 100,000 head of cattle had died on the range for lack of water, the World Food Program of the United Nations instituted a famine relief programme which has grown to include 180,000 people, over 30 per cent of the population (Government of Botswana, 1966). This programme did not touch the Dobe area in the isolated northwest corner of the country and the Herero and Tswana women there were able to feed their families only by joining the Bushman women to forage for wild foods. Thus the natural plant resources of the Dobe area were carrying a higher proportion of population than would be the case in years when the Bantu harvested crops. Yet this added pressure on the land did not seem to adversely affect the Bushmen.

In one sense it was unfortunate that the period of my fieldwork happened to coincide with the drought, since I was unable to witness a 'typical' annual subsistence cycle. However, in another sense, the coincidence was a lucky one, for the drought put the Bushmen and their subsistence system to the acid test and, in terms of adaptation to scarce resources, they passed with flying colours. One can postulate that their subsistence base would be even more substantial during years of higher rainfall.

What are the crucial factors that make this way of life possible? I suggest that the primary factor is the Bushmen's strong emphasis on vegetable food sources. Although hunting involves a great deal of effort and prestige, plant foods provide from 60–80 per cent of the annual diet by weight. Meat has come to be regarded as a special treat; when available, it is welcomed as a break from the routine of vegetable foods, but it is never depended upon as a staple. No one ever goes hungry when hunting fails.

The reason for this emphasis is not hard to find. Vegetable foods are abundant, sedentary and predictable. They grow in the same place year after year, and the gatherer is guaranteed a day's return of food for a day's expenditure of energy. Game animals, by contrast, are scarce, mobile, unpredictable and difficult to catch. A hunter has no guarantee of success and may in fact go for days or weeks without killing a large mammal. During the study period, there were 11 men in the Dobe camp, of whom four did no hunting at all. The seven active men spent a total of 78 man-days hunting, and this work input yielded 18 animals killed, or one kill for every four man-days of hunting. The probability of any one hunter making a kill on a given day was 0.23. By contrast, the probability of a woman finding plant food on a given day was 1.00. In other words, hunting and gathering are not equally felicitous subsistence alternatives.

Consider the productivity per man-hour of the two kinds of subsistence activities. One man-hour of hunting produces about 100 edible calories, and of gathering, 240 calories. Gathering is thus seen to be 2.4 times more productive than hunting. In short, hunting is a *high-risk*, *low-return* subsistence activity, while gathering is a *low-risk*, *high-return* subsistence activity.

It is not at all contradictory that the hunting complex holds a central place in the Bushman ethos and that meat is valued more highly than vegetable foods (Marshall, 1960). Analogously, steak is valued more highly than potatoes in the food preferences of our own society. In both situations the meat is more 'costly' than the vegetable food. In the Bushman case, the cost of food can be measured in terms of time and energy expended. By this standard, 1000 calories of meat 'costs' 10 man-hours, while the 'cost' of 1000 calories of vegetable foods is only four man-hours. Further, it is to be expected that the less predictable, more expensive food source would have a greater accretion of myth and ritual built up around it than would the routine staples of life, which rarely if ever fail.

Eskimo–Bushman comparisons

Were the Bushmen to be deprived of their vegetable food sources, their life would become much more arduous and precarious. This lack of plant foods, in fact, is precisely the situation among the Netsilik Eskimo, reported by Balikci (1968). The Netsilik and other Central Arctic peoples are perhaps unique in the almost total absence of vegetable foods in their diet. This factor, in combination with the great cyclical variation in the numbers and distribution of Arctic fauna, makes Eskimo life the most precarious human adaptation on earth. In effect, *the kinds of animals that are 'luxury goods' to many hunters and gatherers, are to the Eskimos, the absolute necessities of life*. However, even this view should not be exaggerated, since most of the Eskimos in historic times have lived south of the Arctic Circle (Laughlin, 1968) and many of the Eskimos at all latitudes have depended primarily on fishing, which is a much more reliable source of food than is the hunting of land and sea mammals.

What Hunters Do for a Living: A Comparative Study

I have discussed how the !Kung Bushmen are able to manage on the scarce resources of their inhospitable environment. The essence of their successful strategy seems to be that while they depend primarily on the more stable and abundant food sources (vegetables in their case), they are nevertheless willing to devote considerable energy to the less reliable and more highly valued food sources such as medium and large mammals. The steady but modest input of work by the women provides the former, and the more intensive labours of the men provide the latter. It would be theoretically possible for the Bushmen to survive entirely on vegetable foods, but life would be boring indeed without the excitement of meat feasts. The totality of their subsistence activities thus represents an outcome of two individual goals; the first is the desire to live well with adequate leisure time, and the second is the desire to enjoy the rewards, both social and nutritional, afforded by the killing of game. In short, *the Bushmen of the Dobe area eat as much vegetable food as they need, and as much meat as they can.*

It seems reasonable that a similar kind of subsistence strategy would be characteristic of hunters and gatherers in general. Wherever two or more kinds of natural foods are available, one would predict that the population exploiting them would emphasize the more reliable source. We would also expect, however, that the people would not neglect the alternative means of subsistence. The general view offered here is that gathering activities, for plants and shellfish, should be the most productive of food for hunting and gathering man, followed by fishing, where this source is available. The hunting of mammals is the least reliable source of food and should be generally less important than either gathering or fishing.

In order to test this hypothesis, a sample of 58 societies was drawn from the *Ethnographic Atlas* (Murdock, 1967). The basis for inclusion in the sample was a

100 per cent dependence on hunting, gathering and fishing for subsistence as rated in Columns 7–11 of the Atlas (Murdock, 1967, pp154–155). These 58 societies are plotted in Figures 1.1 and 1.2 and are listed in Tables 1.7 and 1.8 of the Appendix to this chapter.[8, 9]

The *Ethnographic Atlas* coding discusses 'Subsistence Economy' as follows:

> A set of five digits indicates the estimated relative dependence of the society on each of the five major types of subsistence activity. The first digit refers to the gathering of wild plants and small land fauna; the second, to hunting, including trapping and fowling; the third, to fishing, including shell fishing and the pursuit of large aquatic animals; the fourth, to animal husbandry; the fifth, to agriculture (Murdock, 1967, pp154–55).

Two changes have been made in the definitions of subsistence. First, the participants at the symposium on Man the Hunter agreed that the 'pursuit of large aquatic animals' is more properly classified under hunting than under fishing. Similarly, it was recommended that shellfishing should be classified under gathering, not fishing. These suggestions have been followed and the definitions now read: *Gathering* – collecting of wild plant, small land fauna and shellfish; *Hunting* – pursuit of land and sea mammals; *Fishing* – obtaining of fish by any technique. In 25 cases, the subsistence scores have been changed in light of these definitions and after consulting ethnographic sources.[10]

In Tables 1.9 and 1.10 of the Appendix to this article, the percentage dependence on gathering, hunting and fishing, and the most important single source of food for each society are presented. Such scores can be at best only rough approximations; however, the results are so striking that the use of these scores seems justified. In the Old World and South American sample of 24 societies, 16 depend on gathering, five on fishing, while only three depend primarily on mammal hunting: the Yukaghir of northeast Asia, and the Ona and Shiriana of South America. In the North American sample, 13 societies have primary dependence on gathering, 13 on fishing, and eight on hunting. Thus for the world as a whole, half of the societies (29 cases) emphasize gathering, one-third (18 cases) fishing, and the remaining one-sixth (11 cases) hunting.

On this evidence, the 'hunting' way of life appears to be in the minority. The result serves to underline the point made earlier that mammal hunting is the least reliable of the subsistence sources, and one would expect few societies to place primary dependence on it. As will be shown, most of the societies that rely primarily on mammals do so because their particular habitats offer no viable alternative subsistence strategy.

The relation of latitude to subsistence

The peoples we have classified as 'hunters' apparently depend for most of their subsistence on sources *other* than meat, namely, wild plants, shellfish and fish. In fact the present sample over-emphasizes the incidence of hunting and fishing since

Table 1.6 *Primary subsistence source by latitude*

Degrees from the equator	*Primary subsistence source*			
	Gathering	*Hunting*	*Fishing*	*Total*
More than 60°	—	6	2	8
50°–59°	—	1	9	10
40°–49°	4	3	5	12
30°–39°	9	—	—	9
20°–29°	7	—	1	8
10°–19°	5	—	1	6
0°–9°	4	1	—	5
World	29	11	18	58

some three-fifths of the cases (34/58) are drawn from North America (north of the Rio Grande) a region which lies entirely within the temperate and arctic zones. Since the abundance and species variety of edible plants decreases as one moves out of the tropical and temperate zones, and approaches zero in the arctic, it is essential that the incidence of hunting, gathering and fishing be related to latitude.

Table 1.6 shows the relative importance of gathering, hunting and fishing within each of seven latitude divisions. Hunting appears as the dominant mode of subsistence *only* in the highest latitudes (60 or more degrees from the equator). In the arctic, hunting is primary in six of the eight societies. In the cool to cold temperate latitudes, 40 to 59 degrees from the equator, fishing is the dominant mode, appearing as primary in 14 out of 22 cases. In the warm-temperate, subtropical and tropical latitudes, zero to 39 degrees from the equator, gathering is by far the dominant mode of subsistence, appearing as primary in 25 of the 28 cases.

For modern hunters, at any rate, it seems legitimate to predict a hunting emphasis only in the arctic, a fishing emphasis in the mid–high latitudes, and a gathering emphasis in the rest of the world.[11]

The importance of hunting

Although hunting is rarely the primary source of food, it does make a remarkably stable contribution to the diet. Fishing appears to be dispensable in the tropics, and a number of northern peoples manage to do without gathered foods, but, with a single exception, *all* societies at all latitudes derive at least 20 per cent of their diet from the hunting of mammals. Latitude appears to make little difference in the amount of hunting that people do. Except for the highest latitudes, where hunting contributes over half of the diet in many cases, hunted foods almost everywhere else constitute 20 to 45 per cent of the diet. In fact, the mean, the median and the mode for hunting all converge on a figure of 35 per cent for hunter-gatherers at all latitudes. This percentage of meat corresponds closely to the 37 per cent noted in the diet of the !Kung Bushmen of the Dobe area. It is evident that the !Kung, far from being an aberrant case, are entirely typical of the hunters in general in the amount of meat they consume.

Conclusions

Three points ought to be stressed. First, life in the state of nature is not necessarily nasty, brutish and short. The Dobe-area Bushmen live well today on wild plants and meat, in spite of the fact that they are confined to the least productive portion of the range in which Bushman peoples were formerly found. It is likely that an even more substantial subsistence base would have been characteristic of these hunters and gatherers in the past, when they had the pick of African habitats to choose from.

Second, the basis of Bushman diet is derived from sources other than meat. This emphasis makes good ecological sense to the !Kung Bushmen and appears to be a common feature among hunters and gatherers in general. Since a 30 to 40 per cent input of meat is such a consistent target for modern hunters in a variety of habitats, is it not reasonable to postulate a similar percentage for prehistoric hunters? Certainly the absence of plant remains on archaeological sites is by itself not sufficient evidence for the absence of gathering. Recently abandoned Bushman campsites show a similar absence of vegetable remains, although this paper has clearly shown that plant foods comprise over 60 per cent of the actual diet.

Finally, one gets the impression that hunting societies have been chosen by ethnologists to illustrate a dominant theme, such as the extreme importance of environment in the moulding of certain cultures. Such a theme can be best exemplified by cases in which the technology is simple and/or the environment is harsh. This emphasis on the dramatic may have been pedagogically useful, but unfortunately it has led to the assumption that a precarious hunting subsistence base was characteristic of all cultures in the Pleistocene. This view of both modern and ancient hunters ought to be reconsidered. Specifically I am suggesting a shift in focus away from the dramatic and unusual cases, and towards a consideration of hunting and gathering as a persistent and well-adapted way of life.

Appendix

Table 1.7 *The sample of hunter-gatherers (excluding North America)*

People (Atlas No.)	*Latitude and longitude (degrees)*
AFRICA $n = 5$	
1. !Kung Bushmen (Aa1)	20S, 21E
2. Dorobo (Aa2)	2S, 36E
3. Mbuti Pygmies (Aa5)	2N, 28E
4. Hadza (Aa9)	3S, 35E
5. Gwi Bushmen (1)	22S, 23E
ASIA $n = 5$	
6. Gilyak (Eci)	53N, 142E
7. Yukaghir (Ec6)	70N, 145E
8. Ainu (Ec7)	44N, 144E
9. Andamanese (Eh1)	12N, 93E
10. Semang (Ej3)	6N, 101E
AUSTRALIA $n = 6$	
11. Aranda (Id1)	24S, 134E
12. Murngin (Id2)	12S, 136E
13. Tiwi (Id3)	12S, 131E
14. Dieri (Id4)	28S, 138E
15. Wikmunkan (Id6)	14S, 142E
16. Walbiri (2)	22S, 133E
SOUTH AMERICA $n = 8$	
17. Paraujano (Sb5)	11N, 72W
18. Shiriana (Sd6)	4N, 63W
19. Yahgan (Sg1)	55S, 69W
20. Ona (Sg3)	54S, 69W
21. Alacaluf (Sg5)	52S, 74W
22. Chamacoco (Sh6)	20S, 59W
23. Aweikoma (Sj3)	28S, 50W
24. Botocudo (Sj5)	18S, 42W

Table 1.8 *The North American sample*

People (Atlas No.)	*Latitude and longitude (degrees)*
1. Copper Eskimo (Na3)	69N, 110W
2. Kaska (Na4)	59N, 128W
3. Ingalik (Na8)	62N, 160W
4. Chugach (Na10)	60N, 166W
5. Nunamiut (Na12)	68N, 152W
6. Kutchin (Na20)	66N, 135W
7. Chipewyan (Na30)	60N, 105W
8. Montagnais (Na32)	48N, 72W
9. Northern Saulteaux (Na33)	52N, 98W
10. Eyak (Nb5)	60N, 145W
11. Tsimshian (Nb7)	55N, 130W
12. Quileute (Nb18)	48N, 125W
13. Chinook (Nb19)	46N, 124W
14. Tlingit (Nb22)	58N, 134W
15. Bellabella (Nb23)	52N, 128W
16. Cowichan (Nb26)	49N, 123W
17. Tututni (Nb31)	42N, 124W
18. Chimariko (Nb33)	41N, 123W
19. Tubatulabal (Nc2)	36N, 118W
20. Diegueno (Nc6)	32N, 116W
21. Modoc (Nc9)	43N, 122W
22. Achomawi (Nc10)	41N, 121W
23. Wintu (Nc14)	41N, 122W
24. Coast Yuki (Nc15)	39N, 124W
25. Lake Yokuts (Nc24)	36N, 120W
26. Cahuilla (Nc31)	33N, 116W
27. Washo (Nd6)	39N, 120W
28. Chilcotin (Nd8)	52N, 122W
29. Flathead (Nd12)	46N, 113W
30. Umatilla (Nd19)	46N, 119W
31. Panamint (Nd32)	36N, 117W
32. Kaibab (Nd53)	36N, 113W
33. Yavapai (Nd66)	35N, 112W
34. Seri (Ni4)	29N, 112W

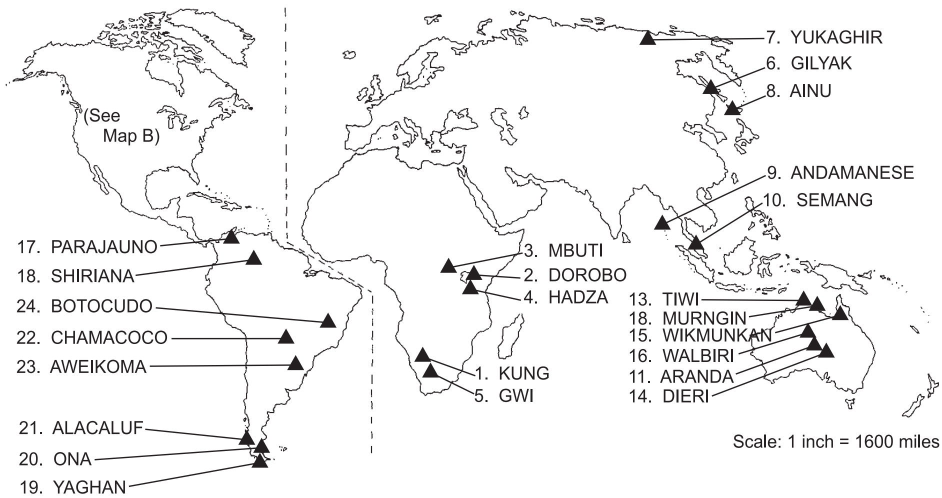

Figure 1.1 *Old World and South American Hunter-gatherers*

Table 1.9 *Subsistence base of hunter-gatherers (Old World and South America)*

	Percentage dependence on:			Primary subsistence source		
People	*Gathering*	*Hunting*	*Fishing*			
1. !Kung Bushman[a]	70	30	0	G		
2. Dorobo[a]	60	40	0	G		
3. Mbuti	60	30	10	G		
4. Hadza[a]	80	20	0	G		
5. Gwi Bushmen	70	30	0	G		
6. Gilyak[a]	30	30	40			F
7. Yukaghir[a]	10	60	30		H	
8. Ainu[a]	30	30	40			F
9. Andamanese[a]	50	20	30	G		
10. Semang	40	30	30	G		
11. Aranda[a]	70	30	0	G		
12. Murngin[a]	60	30	10	G		
13. Tiwi[a]	60	30	10	G		
14. Dieri	70	30	0	G		
15. Wikmunkan[a]	60	30	10	G		
16. Walbiri	70	30	0	G		
17. Paraujano[a]	40	10	50			F
18. Shiriana	30	40	30		H	
19. Yahgan[a]	30	20	50			F
20. Ona	20	60	20		H	

Table 1.9 *(continued)*

People	*Percentage dependence on:* Gathering	Hunting	Fishing	*Primary subsistence source*		
22. Chamacoco	60	40	0	G		
23. Aweikoma[a]	60	40	0	G		
24. Botocudo	50	40	10	G		
Total				16	3	5

[a] In some of the cases marked, the subsistence percentages have been changed from those published in the *Ethnographic Atlas*. The categories have been redefined so that shell fishing is included under 'Gathering', and pursuit of sea-mammals under 'Hunting'. In the *Atlas*, both are included under 'Fishing'.

Figure 1.2 *North American Hunter-gatherers*

Table 1.10 *Subsistence base of hunter-gatherers (North America)*

People	Percentage dependence on: Gathering	Hunting	Fishing	Primary subsistence source		
1. Copper Eskimo[a]	0	55	45		H	
2. Kaska	10	40	50			F
3. Ingalik	10	40	50			F
4. Ghugach[a]	10	60	30		H	
5. Nunamiut	10	70	20		H	
6. Kutchin	10	40	50			F
7. Chipewyan	0	60	40		H	
8. Montagnais	20	60	20		H	
9. Saulteaux	20	35	45			F
10. Eyak[a]	20	45	35		H	
11. Tsimshian[a]	20	30	50			F
12. Quilcute[a]	30	30	40			F
13. Chinook[a]	30	20	50			F
14. Tlingit[a]	10	40	50			F
15. Bellabella	20	30	50			F
16. Cowichan[a]	40	30	30	G		
17. Tututni[a]	45	20	35	G		
18. Chimariko	40	30	30	G		
19. Tubatulabal	50	30	20	G		
20. Diegueno	50	40	10	G		
21. Modoc	50	30	20	G		
22. Achomawi	30	40	30		H	
23. Wintu	30	30	40			F
24. Coast Yuki[a]	60	20	20	G		
25. Lake Yokuts	50	20	30	G		
26. Cahuilla	60	40	0	G		
27. Washo	40	30	30	G		
28. Chilcotin	20	30	50			F
29. Flathead	30	40	30		H	
30. Umatilla	30	30	40			F
31. Panamint	60	40	0	G		
32. Kaibab	70	30	0	G		
33. Yavapai	60	40	0	G		
34. Seri[a]	30	20	50			F
Total (North America)				13	8	13
Total (World)				29	11	18

[a] In some of the cases marked, the subsistence percentages have been changed from those published in the *Ethnographic Atlas*. The categories have been redefined so that shell fishing is included under 'Gathering', and pursuit of sea-mammals under 'Hunting'. In the *Atlas*, both are included under 'Fishing'.

Notes

1 These data are based on 15 months of field research from October 1963, to January 1965. I would like to thank the National Science Foundation (US) for its generous financial support. This paper has been substantially revised since being presented at the symposium on Man the Hunter.

2 The Nyae Nyae !Kung Bushmen studied by Lorna Marshall (1957, 1960, 1965) have been involved in a settlement scheme instituted by the South African government. Although closely related to the Nyae Nyae !Kung, the Dobe !Kung across the border in Botswana have not participated in the scheme.

3 Bushman group structure is discussed in more detail in Lee (1965, pp38–53; and Chapter 17c, this volume).

4 Listed in order of their importance, the principal species in the diet are: wart hog, kudu, duiker, steenbok, gemsbok, wildebeeste, springhare, porcupine, ant bear, hare, guinea fowl, francolin (two species), korhaan, tortoise and python.

5 This and the following topic are discussed in greater detail in Lee, '!Kung Bushman Subsistence: An Input-Output Analysis' (in press).

6 Lenski, for example, in a recent review of the subject, states: 'Unlike the members of hunting and gathering societies [the horticulturalists] are not compelled to spend most of their working hours in the search for food and other necessities of life, but are able to use more of their time in other ways' (1966, p121).

7 During future fieldwork with the !Kung Bushmen, a professional paediatrician and nutritionist are planning to examine children and adults as part of a general study of hunter-gatherer health and nutrition sponsored by the US National Institutes of Health and the Wenner-Gren Foundation for Anthropological Research.

8 Two societies, the Gwi Bushmen and the Walbiri of Australia, were not coded by the *Ethnographic Atlas*. Their subsistence base was scored after consulting the original ethnographies (for the Gwi, Silberbauer, 1965; for the Walbiri, Meggitt, 1962, 1964).

9 In order to make more valid comparisons, I have excluded from the sample mounted hunters with guns such as the Plains Indians, and casual agriculturalists such as the Gê and Siriono. Twenty-four societies are drawn from Africa, Asia, Australia and South America. This number includes practically all of the cases that fit the definition. North America alone, with 137 hunting societies, contains over 80 per cent of the 165 hunting societies listed in the *Ethnographic Atlas*. The sampling procedure used here was to choose randomly one case from each of the 34 'clusters' of North American hunter-gatherers.

10 For their useful suggestions, my thanks go to Donald Lathrap, Robin Ridington, George Silberbauer, Hitoshi Watanabe and James Woodburn. Special thanks are due to Wayne Suttles for his advice on Pacific coast subsistence.

11 When severity of winter is plotted against subsistence choices, a similar picture emerges. Hunting is primary in three of the five societies in very cold climates (annual temperature less than 32° F); fishing is primary in 10 of the 17 societies in cold climates (32°–50° F); and gathering is primary in 27 of the 36 societies in mild to hot climates (over 50° F).

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2

Foragers and Others

Richard B. Lee and Richard Daly

Recently an aboriginal guide was showing a group of tourists around Alberta's renowned Head-Smashed-In Buffalo-Jump, a UNESCO World Heritage Site staffed by First Nations personnel. The guide graphically described how in ancient times the buffalo would be driven over the edge of a 15-metre precipice, to land in a gory heap at the base of the cliff. A diorama showed men and women clambering over the bodies to club and spear those still living. When one tourist expressed shock at the bloody nature of the enterprise, the guide responded simply but with conviction, 'We were hunters!' connecting her own generation with those of the past. She then amended her statement with equal conviction, adding, 'Humans were hunters!' thus expanding complicity in the act of carnage to the whole of humanity, not excluding her interlocutor.

This incident summarizes neatly the historical conjuncture that brings *The Cambridge Encyclopedia of Hunters and Gatherers* to fruition. The world's hunting and gathering peoples – the Arctic Inuit, Aboriginal Australians, Kalahari San and similar groups – represent the oldest and perhaps most successful human adaptation. Until 12,000 years ago virtually all humanity lived as hunters and gatherers. In recent centuries hunters have retreated precipitously in the face of the steamroller of modernity. However, fascination with hunting peoples and their ways of life remains strong, a fascination tinged with ambivalence. The reason for public and academic interest is not hard to find. Hunters and gatherers stand at the opposite pole from the dense urban life experienced by most of humanity. Yet these same hunters may hold the key to some of the central questions about the human condition – about social life, politics and gender, about diet and nutrition and living in nature: how people can live and have lived without the state; how to live without accumulated technology; the possibility of living in Nature without destroying it. This book offers no simple answers to these questions. Hunter-gatherers are a diverse group of peoples living in a wide range of conditions. One of the themes of the book is the exploration of that diversity. Yet within the range

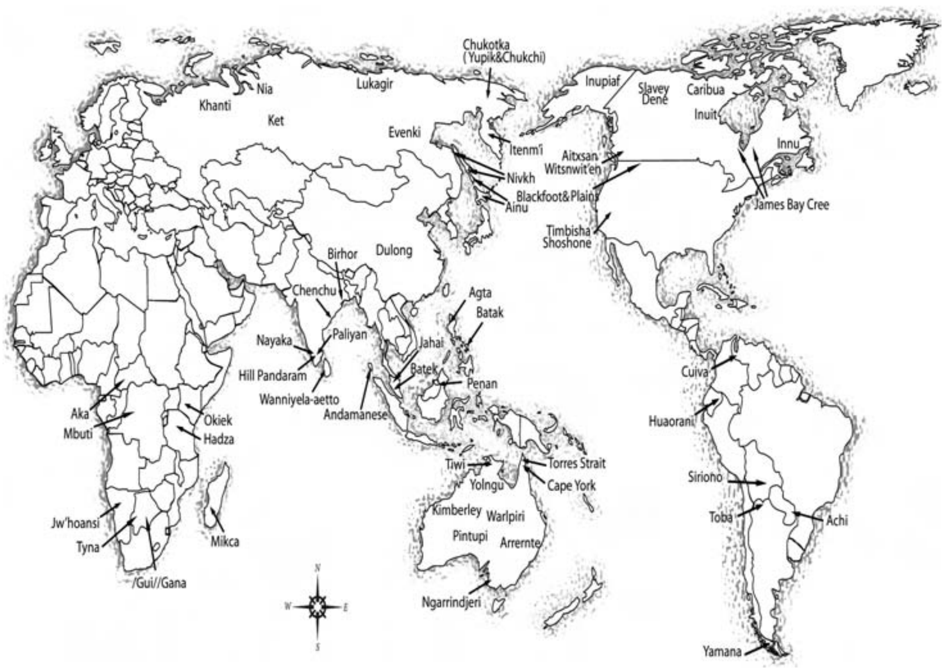
Lee R B and Daly R. Foragers and others. In Lee R B and Daly R (eds). *Cambridge Encyclopedia of Hunters and Gatherers*, 1999, Cambridge University Press, Cambridge.

of variation, certain common motifs can be identified. Hunter-gatherers are generally peoples who have lived until recently without the overarching discipline imposed by the state. They have lived in relatively small groups, without centralized authority, standing armies or bureaucratic systems. Yet the evidence indicates that they have lived together surprisingly well, solving their problems among themselves largely without recourse to authority figures and without a particular propensity for violence. It was not the situation that Thomas Hobbes, the great 17th-century philosopher, described in a famous phrase as 'the war of all against all'. By all accounts life was not 'nasty, brutish and short'. With relatively simple technology – wood, bone, stone, fibres – they were able to meet their material needs without a great expenditure of energy, leading the American anthropologist and social critic Marshall Sahlins to call them, in another famous phrase, 'the original affluent society'. Most striking, the hunter-gatherers have demonstrated the remarkable ability to survive and thrive for long periods – in some cases thousands of years – without destroying their environment.

The contemporary industrial world lives in highly structured societies at immensely higher densities and enjoys luxuries of technology that foragers could hardly imagine. Yet all these same societies are sharply divided into haves and have-nots, and after only a few millennia of stewardship by agricultural and industrial civilizations, the environments of large parts of the planet lie in ruins. Therefore the hunter-gatherers may well be able to teach us something, not only about past ways of life but also about long-term human futures. If technological humanity is to survive it may have to learn the keys to longevity from fellow humans whose way of life has been around a lot longer than industrial commercial 'civilization'. As Burnum Burnum, the late Australian Aboriginal writer and lecturer, put it, 'Modern ecology can learn a great deal from a people who managed and maintained their world so well for 50,000 years.'

Hunter-gatherers in recent history have been surprisingly persistent. As recently as AD 1500 hunters occupied fully one-third of the globe, including all of Australia and most of North America, as well as large tracts of South America, Africa and North-east Asia. The 20th century has seen particularly dramatic changes in their life circumstances. The century began with dozens of hunting and gathering peoples still pursuing ancient (though not isolated) lifeways in small communities, as foragers with systems of local meaning centred on kin, plants, animals and the spirit world. As the century proceeded, a wave of self-appointed civilizers washed over the world's foragers, bringing schools, clinics and administrative structures, and, not incidentally, taking their land and resources.

The year 2000 will have seen the vast majority of former foragers settled and encapsulated in the administrative structures of one state or another. And given their tragic history of forced acculturation one would imagine that the millennium will bring to a close a long chapter in human history. But will it? We believe not. Hunter-gatherers live on, not only in the pages of anthropological and historical texts, but also, in 40 countries, in the presence of hundreds of thousands of descendants a generation or two removed from a foraging way of life, and these



Map 2.1 *Case studies in the* Cambridge Encyclopedia of Hunters and Gatherers

peoples and their supporters are creating a strong international voice for indigenous peoples and their human rights.

Among the public-at-large, images of hunters and gatherers have swung between two poles. For centuries they were regarded as 'savages', variously ignorant or cunning, beyond the pale of 'civilization'. This distorted image was usually associated with settler societies who coveted the foragers' land; the negative stereotypes justified dispossession.

In recent years a different view has dominated, with hunter-less gatherers as the repository of virtues seemingly lacking in the materialism and marked inequalities of contemporary urban life. How to balance these two views? For many current observers the contrast between savage inequities of modernity and the relative egalitarianism of the so-called 'primitives' gives the latter more weight on the scales of natural justice. Jack Weatherford's eloquently argued book, *Savages and Civilization: Who Will Survive?* (1994), draws on a long intellectual tradition dating from Rousseau which, contemplating the horrors of the modern world, raises the question of who are the truly civilized: the 'savage' with his occasional blood-feud, or the 'civilized' who gave the world the Inquisition, the Atlantic slave trade, the Catling gun, napalm, Hiroshima and the Holocaust? (For an opposing view see Robert Edgerton's *Sick Societies* [1992].)

The present work thus grows out of the intersection between three discourses: anthropological knowledge, public fascination and indigenous peoples' own worldviews. The *Encyclopedia* speaks to scholars, to general readers, and particularly to the members of the cultures themselves. The book offers an up-to-date and encyclopedic inventory of hunters and gatherers, written in accessible language by recognized authorities, some of whom are representatives of the cultures they write about.

Foraging Defined

Foraging refers to subsistence based on hunting of wild animals, gathering of wild plant foods, and fishing, with no domestication of plants, and no domesticated animals except the dog. In contemporary theory this minimal definition is only the starting point in defining hunter-gatherers. Recent research has brought a more nuanced understanding of the issue of who the hunters are and why they have persisted. While it is true that hunting and gathering represent the original condition of humankind and 90 per cent of human history, the contemporary people called hunter-gatherers arrived at their present condition by a variety of pathways.

At one end of a continuum are the areas of the world where modern hunter-gatherers have persisted in a more or less direct tradition of descent from ancient hunter-gatherer populations. This would characterize the aboriginal peoples of Australia, north-western North America, the southern cone of South America and pockets in other world areas. The Australian Pintupi, Arrernte and Warlpiri, the North American Eskimo, Shoshone and Cree, the South American Yamana, and the African Ju/'hoansi are examples of this first grouping, represented in case studies in this volume. In pre-colonial Australia and parts of North America we come closest to Marshall Sahlins' rubric of 'hunters in a world of hunters' (Lee and DeVore 1968). But even here the histories offer examples of complex interrelations between foragers and others.

Along the middle of the continuum are hunting and gathering peoples who have lived in degrees of contact and integration with non-hunting societies, and these include a number whose own histories include life as farmers and/or herders in the past. South and South-east Asian hunter-gatherers are linked to settled villagers and their markets, trading forest products: furs, honey, medicinal plants and rattan, for rice, metals and consumer goods. Some of these arrangements have persisted for millennia. Similar arrangements are seen in central Africa where Pygmies have lived for centuries in patron–client relations with settled villagers while still maintaining a period of the year when they lived more autonomously in the forest. And in East Africa the foraging Okiek traditionally supplied honey and other forest products to neighbouring Maasai and Kipsigis.

South American hunter-gatherers present an even more interesting case, since archaeological evidence indicates that in Amazonia farming replaced foraging several millennia ago. In the view of Anna Roosevelt, much of the foraging observed in *tropical* South America represents a secondary readaptation. After the European conquests of the 16th–18th centuries many groups found that mobile hunting and gathering made them less vulnerable to colonial exploitation. Other groups had been operating this way far longer, back into the pre-colonial period. And almost all *tropical* South American foragers today plant gardens as one part of their annual trek. There are parallels here with Siberia, where most of the 'small peoples' classified as hunter-gatherers also herded reindeer, a practice which greatly expanded during the Soviet period.

Finally, at the other end of the continuum are peoples who once were hunters but who changed their subsistence in the more distant past. And that includes the rest of us: the 5-billion-strong remainder of humanity.

Social Life

In defining foragers we must recognize that contemporary foragers practise a mixed subsistence: gardening in tropical South America, reindeer herding in northern Asia, trading in South/South-east Asia and parts of Africa. Given this diversity, what constitutes the category 'hunter-gatherer'? The answer is that subsistence is one part of a multifaceted definition of hunter-gatherers: social organization forms a second major area of convergence, and cosmology and worldview a third. All three sets of criteria have to be taken into account in understanding hunting and gathering peoples today.

The basic unit of social organization of most (but not all) hunting and gathering peoples is the *band*, a small-scale nomadic group of 15–50 people related by kinship. Band societies are found throughout the Old and New Worlds and share a number of features in common. Most observers would agree that the social and economic life of *small-scale* hunter-gatherers shares the following features.

First they are relatively *egalitarian*. Leadership is less formal and more subject to constraints of popular opinion than in village societies governed by headmen and chiefs. Leadership in band societies tends to be by example, not by fiat. The leader can persuade but not command. This important aspect of their way of life allowed for a degree of freedom unheard of in more hierarchical societies but it has put them at a distinct disadvantage in their encounters with centrally organized colonial authorities.

Mobility is another characteristic of band societies. People tend to move their settlements frequently, several times a year or more, in search of food, and this mobility is an important element of their politics. People in band societies tend to 'vote with their feet', moving away rather than submitting to the will of an unpopular leader. Mobility is also a means of resolving conflicts that would be more difficult for settled peoples.

A third characteristic is the remarkable fact that all band-organized peoples exhibit a pattern of *concentration and dispersion*. Rather than living in uniformly sized groupings throughout the year, band societies tend to spend part of the year dispersed into small foraging units and another part of the year aggregated into much larger units. The Innu (Naskapi) discussed by Mailhot would spend the winter dispersed in small foraging groups of 10–30, while in the summer they would aggregate in groups of up to 200–300 at lake or river fishing sites. It seems clear that the concentration/dispersion patterns of hunter-gatherers represent a dialectical interplay of social *and* ecological factors.

A fourth characteristic common to almost all band societies (and hundreds of village-based societies as well) is a land tenure system based on a *common property regime (CPR)*. These regimes were, until recently, far more common worldwide than regimes based on private property. In traditional CPRs, while movable property is held by individuals, land is held by a kinship-based collective. Rules of reciprocal access make it possible for each individual to draw on the resources of several territories. Rarer is the situation where the whole society has unrestricted access to all the land controlled by the group.

Ethos and Worldview

Another broad area of commonalities lies in the domains of the quality of interpersonal relations and forms of consciousness.

Sharing is the central rule of social interaction among hunters and gatherers. There are strong injunctions on the importance of reciprocity. Generalized reciprocity, the giving of something without an immediate expectation of return, is the dominant form within face-to-face groups. Its presence in hunting and gathering societies is almost universal (Sahlins 1965). This, combined with an absence of private ownership of land, has led many observers from Lewis Henry Morgan forward to attribute to hunter-gatherers a way of life based on 'primitive communism' (Morgan, 1881; Testart, 1985; Lee, 1988).

Found among many but not all hunter-gatherers is the notion of the *giving environment*, the idea that the land around them is their spiritual home and the source of all good things (Turnbull, 1965; Bird-David, 1990). This view is the direct antithesis of the Western Judeo-Christian perspective on the natural environment as a 'wilderness', a hostile space to be subdued and brought to heel by the force of will. This latter view is seen by many ecological humanists as the source of both the environmental crisis and the spiritual malaise afflicting contemporary humanity (Shiva, 1988, 1997; Suzuki, 1989, 1992, 1997).

Hunter-gatherers are peoples who live with nature. When we examine the *cosmology* of hunting and gathering peoples, one striking commonality is the view of nature as animated with moral and mystical force, in Robert Bellah's phrase 'the hovering closeness of the world of myth to the actual world' (1965, p19). As discussed by Mathias Guenther (*Cambridge Encyclopedia of Hunters and Gatherers*), the world of hunter-gatherers is a multilayered world, composed of two or more planes: an above/beyond zone and an underworld in addition to the present world inhabited by humans. There are invariably two temporal orders of existence, with an Early mythical or 'dreamtime' preceding the present. In the former, nature and culture are not yet fully separated. Out of this Ur-existence, a veritable cauldron of cultural possibilities, crystallizes the distinction between humans and animals, the origin of fire, cooking, incest taboos, even mortality itself and virtually everything of cultural significance.

The world of the Past and the above-and-below world of myth are in intimate contact with the normal plane of existence. The Australian Aborigines present the most fully realized instance of this process of world-enchantment. The famous 'songlines' of the Dreamtime criss-cross the landscape and saturate it with significance. Every rock and feature has symbolic meaning and these are bound up in the reproduction of life itself. It is these totemic elements that are the sources of the spirit children that enter women's wombs and trigger conception. Parallels are found in many other hunter-gatherer groups.

The *Trickster* is a central figure in the myth worlds of many hunting and gathering societies. A divine figure, but deeply flawed and very human, the Trickster is found in myth cycles from the Americas, Africa, Australia and Siberia. Similar figures grace the pantheons of most village farming and herding peoples as well. The Trickster symbolizes the frailty and human qualities of the gods and their closeness to humans. These stand in pointed contrast to the omnipotent, all-knowing but distant deities that are central to the pantheons of state religions and their powerful ecclesiastical hierarchies (Radin, 1956; Diamond, 1974; Wallace, 1966).

Shamanism is another major practice common to the great majority of hunting and gathering peoples. The word originates in eastern Siberia, from the Evenki/Tungus word *saman* meaning 'one who is excited or raised'. Throughout the hunter-gatherer world community-based ritual specialists (usually part-time) heal the sick and provide spiritual protection. They mediate between the social/human world and the dangerous and unpredictable world of the supernatural. Shamanism is performative, mixing theatre and instrumental acts in order to approach the plane of the sacred. Performances vary widely. Among the Ju/'hoansi the 'owners of medicine', after a long and difficult training period, enter an altered state of consciousness called *Ikia*, to heal the sick through a laying on of hands (Marshall, 1968; Katz, 1982). The northern Ojibwa practised the famous shaking tent ceremony or *midewiwin*, while other shamans used dreams, psychoactive drugs, or intense mental concentration to reach the sacred plane. The brilliant use of language and metaphor in the form of powerful and moving verbal images is a central part of the shaman's craft (Rothenberg, 1968). So powerful are these techniques that they have been widely and successfully adapted to the *visualization therapies* in the treatment of cancer and other conditions in Western medicine.

Ethos and social organization are both essential components of hunter-gatherer lifeways. Laura Rival (*Cambridge Encyclopedia of Hunters and Gatherers*) makes the point that two South American tropical forest peoples may well have a rather similar subsistence mix, but different orientations: analysing them on the basis of their social organization and mobility patterns, as well as mythology, rituals and inter-personal relations, the researcher finds that one has a clearly agricultural orientation, the other a foraging one.

What is remarkable is that, despite marked differences in historical circumstances, foragers seem to arrive at similar organizational and ideational solutions to the problems of living in groups, a convergence that Tim Ingold, the foremost authority on hunter-gatherer social life, has labelled 'a distinct mode of sociality' (*Cambridge Encyclopedia of Hunters and Gatherers*).

Divergences

Despite these commonalities, there are a number of significant divergences among hunters and gatherers. And consideration of these must temper any attempt to present an idealized picture of foraging peoples. First the foragers as a group are not particularly peaceful. *Interpersonal violence* is documented for most and warfare is recorded for a number of hunting and gathering peoples. Although peaceful peoples such as the Malaysian Semang are celebrated in the literature (Dentan, 1968), for many others (Inupiat, Warlpiri, Blackfoot, Aché, Agta) raids and blood-feuds are common occurrences, particularly before the pacification campaigns of the colonial authorities (see for example Ember, 1992; Moss, 1992; Bamforth, 1994). But mention of the colonial context raises another important issue. Did high levels of 'primitive' warfare represent a primordial condition, or were these exacerbated by the pressure of colonial conquest? The question remains an ongoing subject of debate (Divale and Harris, 1976; Ferguson, 1984).

Gender is another dimension in which hunting and gathering societies show considerable variation. As Karen Endicott argues (*Cambridge Encyclopedia of Hunters and Gatherers*), the women of hunter-gatherer societies *do* have higher status than women in most of the world's societies, including industrial and post-industrial modernity. This status is expressed in greater freedom of movement and involvement in decision making and a lower incidence of domestic violence against them when compared to women in farming, herding, and agrarian societies (Leacock, 1978, 1982; Lee, 1982). Nevertheless variation exists: wife-beating and rape are recorded for societies as disparate as those of Alaska (Eskimo) and northern Australian Aborigines (Friedl, 1975; Abler, 1992) and are not unknown elsewhere; nowhere can it be said that women and men live in a state of perfect equality.

A third area of divergence is found in the important distinction between *simple vs. complex* hunter-gatherers. Price and Brown (1985) argued that not all hunting and gathering peoples – prehistoric and contemporary – lived in small mobile bands. Some, like the Indians of the North-west Coast (Donald, 1984, 1997; Mitchell and Donald, 1985) and the Calusa of Florida (Marquardt, 1988), as well as many prehistoric peoples, lived in large semi-sedentary settlements with chiefs, commoners and slaves, yet were entirely dependent on wild foods. In social organization and ethos these societies showed significant divergence from the patterns outlined above, yet in other ways a basic foraging pattern is discernible. For example the North-west Coast peoples still maintained a concentration–dispersion pattern, breaking down their large permanent plank houses in the summer and incorporating them into temporary structures at seasonal fishing sites (Boas, 1966, Daly, *Cambridge Encyclopedia of Hunters and Gatherers*). A related concept is James Woodburn's notion of *immediate-return vs. delayed-return societies* (1982). Although both were subsumed under the heading of 'band society', in immediate-return societies food was consumed on the spot or soon after, while in delayed-return societies food and other resources might he stored for months or years, with marked effects on social organization and cultural notions of property (Woodburn, 1982).

In a superb synthesis Robert L. Kelly has documented these divergences on many fronts in his book *The Foraging Spectrum: Diversity in Hunter-gatherer Lifeways* (1995). Recently Susan Kent (1996b) has attempted a similar exercise for the diversity and variation in the hunting and gathering societies of a single continent, Africa. The point is that hunter-gatherers encompass a wide range of variability and analysts seeking to make sense of them ignore this diversity at their peril!

The Importance of History

Any adequate representation of hunting and gathering peoples in the 21st century has to address the complex historical circumstances in which they are found. Foragers have persisted to the present for a variety of reasons but all have developed historical links with non-foraging peoples, some extending over centuries or millennia. And all have experienced the transformative effects of colonial conquest and incorporation into states. Situating the foraging peoples in history is thus essential to any deeper understanding of them, a point that was often lost on earlier observers who preferred to treat foragers as unmediated visions of the past.

One recent school of thought has questioned the validity of the very concept 'hunter-gatherer'. Starting from the fact that some hunter-gatherers have been dominated by more powerful outsiders for centuries, proponents of this school see contemporary foraging peoples more as victims of colonialism or subalterns at the bottom of a class structure than as exemplars of the hunting and gathering way of life (Schrire, 1984; Wilmsen, 1989; Wilmsen and Denbow, 1990). This 'revisionist' view sees the foragers' simple technology, nomadism and sharing of food as part of a culture of poverty generated by the larger political economy and not as institutions generated by the demands of foraging life. (There is a large and growing literature on both sides of this issue known in recent years as 'the Kalahari Debate'. Readers interested in pursuing this issue should begin with Barnard [1992a]).

While recognizing that many foraging peoples have suffered at the hands of more powerful neighbours and colonizers, *The Cambridge Encyclopedia of Hunters and Gatherers* challenges the view that recent hunter-gatherers are simply victims of colonial forces. Autonomy and dependency are a continuum, not an either/or proposition, and as John Bodley documents (*Cambridge Encyclopedia of Hunters and Gatherers*), despite the damage brought by colonialism, foragers persist and show a surprising resilience. Foragers may persist for a variety of reasons. As illustrated by the example of the Kalahari San of southern Africa, where much of the debate has focused, some San *did* become early subordinates of Bantu-speaking overlords, but many others maintained viable and independent hunter-gatherer lifeways into the 19th and 20th centuries (Solway and Lee, 1990; Guenther, 1993, 1998; Kent, 1996a; Robertshaw, *Cambridge Encyclopedia of Hunters and Gatherers*). Archaeological evidence reviewed by Sadr (1997) strongly supports the position that a number of San peoples maintained a classic Later Stone Age tool kit and a hunting and gathering lifeway into the late 19th century. When Ju/'hoan San people themselves are asked to reflect on their own history they insist that, prior to the arrival of the Europeans in the latter part of the 19th century, they lived as hunters on their own, without cattle, while maintaining links of trade to the wider world (Smith and Lee, 1997).

The general point to be made is that outside links do not automatically make hunter-gatherers subordinate to the will of their trading partners. Exchange is a universal aspect of human culture; all peoples at all times have traded. In the case of recent foragers, trading relations may in fact have allowed foraging peoples to maintain a degree of autonomy and continue to practise a way of life that they valued (Peterson, 1991, 1993).

Another case in point is exemplified by the Toba of the western Argentinian Gran Chaco. Gastón Gordillo (*Cambridge Encyclopedia of Hunters and Gatherers*) notes how the foraging Toba have maintained their base in the Pilcomayo marshes as a partial haven against direct exploitation. As the Toba say, 'At least we have the bush,' seeing their Pilcomayo territory as a refuge to come home to after their annual trips to the plantations to earn necessary cash. The view of the 'bush' as a refuge seems to be a common theme among many hunter-gatherers. What it brings home is that foragers believe in their way of life: foraging for them is a positive choice, not just a result of exclusion by the wider society.

To the contrary, the authors of this book, led by Lakota anthropologist Beatrice Medicine in the Foreword, question whether victimhood at the hands of more powerful peoples is the only or even the main issue of interest about hunters and gatherers. The authors start from the position that the first priority is to represent the life-worlds of contemporary hunter-gatherers faithfully. This invariably includes documenting the peoples' sense of themselves as having a collective history as hunter-gatherers. Whether this foraging represents a primary or secondary adaptation, it often continues because that way of life has meaning for its practitioners. It seems unwise, if not patronizing, to assume that all foragers are primarily so because they were forced into it by poverty or oppression.

It is more illuminating to understand hunter-gatherer history and culture as the product of a complex triple dynamic: part of their culture needs to be understood in terms of the dynamic of the foraging way of life itself, part from the dynamic of their interaction with (often more powerful) non-foraging neighbours, and part from the dynamic of their interaction with the dominant state administrative structures (cf. Leacock and Lee, 1982).

A Brief History of Hunter-gatherer Studies

If a single long-term trend can be discerned in hunter-gatherer studies it is this: studies began with a vast gulf between observers and observed. 18th- and 19th-century treatises on the subject objectified the hunters and treated them as external objects of scrutiny. With the development of field anthropology, observers began to know the foragers as people and the boundaries between observers and observed began to break down. Finally in the most recent period, the production of knowledge has become a two-way process; the role of observer has begun to merge with the role of advocate and the field of hunter-gatherer studies has come to be increasingly influenced by agendas set by the hunter-gatherers themselves (Lee, 1992).

The more formal history of hunter-gatherer studies parallels the history of the discipline of anthropology. The peoples who much later were to become known as 'hunters and gatherers' have been an important element in central debates of European social and political thought from the 16th century forward (Barnes, 1937; Barnes and Becker, 1938; Meek, 1976). As described in the chapter by Alan Barnard (*Cambridge Encyclopedia of Hunters and Gatherers*, Part II), philosophers from Hobbes, Locke and Rousseau onward have drawn upon contemporary accounts of 'savages' as a starting point for speculations about life in the state of nature and what constitutes the good society.

These constructions became more detailed as more information accumulated from travellers' accounts, resulting in elaborate schemes for human social evolution in the works of the 18th-century Scottish Enlightenment – Smith, Millar and Ferguson – as well as on the continent – Diderot, Vico and Voltaire (Barnes, 1937; Harris, 1968).

Well before the 1859 publication of Darwin's *On the Origin of Species* the question of the antiquity of humanity became a central preoccupation of scholars, initiated in part by John Frere's famous 1800 essay which made the then heretical suggestion that teardrop-shaped, worked-stone objects found buried in river gravels at Hoxne, Suffolk, UK in association with extinct mammals may indeed not have been Zeus' thunderbolts, but instead implements made by humans that could be traced 'to a very distant period, far more remote in time than the modern world' (quoted in Boule and Vallois 1957, p11).

With the rise of European imperialism and the conquest of new lands came the beginnings of anthropology as a formal discipline. In the academic division of labour, while sociologists adopted as their mandate understanding urban society of the Western metropole, anthropologists took on the rest of the world: classifying diverse humanity and theorizing about its origins and present condition. The 19th-century classical evolutionists erected elaborate schemes correlating social forms, kinship and marriage with mental development and levels of technology. The world's hunters were usually relegated to the bottom levels. In Lewis Henry Morgan's tripartite scheme, of 'Savagery, Barbarism, and Civilization', hunters were either Lower or Middle Savages, depending on the absence or presence of the bow and arrow (Morgan, 1877).

William Sollas was one of the first to define hunting and gathering as a specific lifeway, and in *Ancient Hunters and their Modern Representatives* (1911) he linked ethnographies of recent hunters with their putative archaeological analogues. Modern Eskimo resembled Magdalenians, African Bushmen stood in for Aurignacians, and so on.

Essential to the development of modern anthropology was the decisive repudiation of the classical evolutionary schemes and their implicit (and often explicit) racism. Franz Boas' watershed study *Race, Language and Culture* (1948) demonstrated that the three core factors varied independently. A 'simple' technology could be associated with a complex cosmology, members of one 'race' could show a wide range of cultural achievements, and all languages possessed the capacity for conveying abstract thought. It was only on the twin foundations of Boasian cultural relativism and the emphasis on fieldwork that modern social and cultural anthropology could develop.

It is striking that most of the founders of the discipline both in North America and in Europe carried out landmark studies of hunters and gatherers. Boas himself went to the Canadian Arctic in 1886 as a physical geographer (his doctoral dissertation was on the colour of sea water), but his ethnographic study of the Central Eskimo (1888) became one of the seminal works in American anthropology. He went on to carry out decades of research with the KwaKwaKa'wakw (Kwakiutl) on the North-west Coast of British Columbia, a classic example of a *complex* hunter-gatherer group (Boas, 1966). Boas' close associates A. L. Kroeber and Robert Lowie also established their reputations through major research on hunting and gathering peoples, Californian and Crow Indians respectively (Kroeber, 1925; Lowie, 1935).

Founders of British anthropology shared a similar early focus, beginning with A. R. Radcliffe-Brown's study of the Andaman Islanders in 1906–1908 (1922). The great Bronislaw Malinowski, before going to the Trobriand Islands, wrote his doctoral dissertation on the family among the Australian Aborigines (1913). In France, while neither did hunter-gatherer fieldwork, both Emile Durkheim and Marcel Mauss carried out intensive library research on foraging peoples, with the former writing about Australian aboriginal religion in *Elementary Forms of the Religious Life* (Durkheim, 1912) and the latter writing his seminal essay on the seasonal life of the Eskimo (Mauss, 1906). Two decades later Claude Lévi-Strauss began his distinguished career with a 1930s field study of the hunting and gathering Nambicuara in the Brazilian Mato Grosso, before returning to Paris to write his influential works on the origins of kinship and mythology (1949, 1962a, 1962b, 1987).

Mention should also be made of the 1898 British expedition, led by A. C. Haddon, to the Torres Strait Islanders with their affinities to the Australian Aborigines, of the American Museum of Natural History's Jesup North Pacific Expedition to Siberia in 1897 (see Grant, 1995), and of the brilliant series of expeditions by Danish anthropologists to Greenland and the Canadian Arctic led by Mattiessen and Rasmussen. Important research traditions can also be discerned in Australia and Russia.

Modern studies of hunting and gathering peoples can be traced arguably to two landmark studies of the 1930s. First is the 1936 essay by Julian Steward who, in a *festschrift* for his mentor, A. L. Kroeber, wrote on 'The social and economic basis of primitive bands' (1936). After four decades of scholarly emphasis on careful description without theory building, Steward sought to revive an interest in placing hunter-gatherer studies in a broader theoretical framework. Steward argued that resource exploitation determined to a significant extent the shape and dynamics of band organization and this ecological approach became one of the two foundations of hunter-gatherer studies for the next 30 years.

The second base was the classic essay by Radcliffe-Brown on Australian Aboriginal social organization (1930–1931). The peripatetic R-B had begun his career in South Africa and from there moved to Sydney, São Paulo and Chicago before taking up the chair in social anthropology at Oxford. During his Australian tenure he wrote a series of influential overviews of Aboriginal social organization. But unlike Steward, for whom *ecological* factors were paramount, R-B saw structural factors of *kinship* as primary. Australian Aboriginal societies were usually divided into moieties, and these dual divisions were often subdivided into four sections or eight subsections. These divisions had profound effects on marriage patterns, producing an intricate and elegant algebra of prescriptive alliances between intermarrying groups. Radcliffe-Brown was far less interested than Steward in what the Aborigines did for a living. While the clan and section membership ruled the kinship universe and nominally held the land, it was the more informal *horde*, a band-like entity, whose members lived together on a daily basis and shouldered the tasks of subsistence.

In the 1940s Radcliffe-Brown's kinship models were taken up by Lévi-Strauss, who placed Australian Aboriginal moieties at the centre of his monumental work *Les Structures élémentaires de la parenté* (1949). It is worthy of note that theories of band organization have continued to be dominated by these two alternative paradigms: an ecological or adaptationist approach which relies on material factors to account for forager social life, and a structural approach which sees kinship, marriage and other such social factors as the primary determinants. The two approaches are by no means incompatible, and although the two tendencies are still discernible in hunter-gatherer studies, many analysts have posited a dialectic of social and ecological forces in the dynamics of forager life (see Sahlins, 1972; Lee, 1979; Leacock, 1982; Peterson, 1991, 1993 and others).

The Man the Hunter Conference

In 1965, Sol Tax announced the convening of a conference on 'Man the Hunter' at the University of Chicago; the conference, organized by Irven DeVore and Richard Lee, took place 6–8 April 1966 and proved to be the starting point of a new era of systematic research on hunting and gathering peoples. One commentator called the Man the Hunter conference 'the century's watershed for knowledge about hunter-gatherers' (Kelly, 1995, p14). Present at the conference were representatives of many of the major constituencies in the field of hunter-gatherer studies (though no hunter-gatherers themselves), including proponents of the *ecological* and *structural* schools. There were critics of the late Radcliffe-Brown's theories as well as supporters; there were archaeologists, demographers and physical anthropologists, reflecting the revival of interest in evolutionary approaches then current in American anthropology. Among the key findings of the Man the Hunter conference were the papers focusing on the relative ease of foraging subsistence, epitomized in Marshall Sahlins' famous 'Notes on the original affluent society' (1968). Gender and the importance of women's work was a second key theme of the conference. The name 'Man the Hunter' was a misnomer since among tropical foragers plant foods, produced largely by women, were the dominant source of subsistence.

After Man the Hunter

A burst of research activity followed the convening of Man the Hunter and the publication of the book of the same title (Lee and DeVore, 1968). Scholars present at the conference brought out their own monographs and edited volumes (Damas, 1969; Balikci, 1970; Bicchieri, 1972; Sahlins, 1972; Watanabe, 1973; Marshall, 1976; Binford, 1978; Lee, 1979; Laughlin, 1980; Helm, 1981; Suttles, 1990).

The field of hunter-gatherer studies has always been a fractious one and consensus is rarely achieved. After 1968 new work critiqued key theses from Man the Hunter. The irony of the mistitle was not lost on feminist anthropologists who produced a series of articles and books with the counter theme of 'Woman the Gatherer' (Slocum, 1975; Hiatt, 1978; Dahlberg, 1981). The feminist critics were certainly taking issue with the concept of Man the Hunter, and not necessarily with the book's content since the latter had gone a long way toward re-establishing the importance of women's work and women's roles in hunter-gatherer society. This last point was taken up in detail by Adrienne Zihlman and Nancy Tanner in an important article which drew upon the evidence assembled in Man the Hunter to place 'woman the gatherer' at the centre of human evolution (Tanner and Zihlman, 1976).

At the same time a counter-counter-discourse developed among scholars who questioned whether women's subsistence contribution had been *overestimated*, and several cross-cultural studies were produced to argue this view, summarized in Kelly (1995, pp261–292). A related development was the discovery that women in hunter-gatherer societies do hunt, the most famous case being that of the Agta of the Philippines.

Original 'affluence' came in for much discussion and critique, with a long series of debates over the definition of affluence and whether it applied to all hunters and gatherers at all times or even to all the !Kung (Hawkes and O'Connell, 1981, 1985; Koyama and Thomas, 1981; Altman, 1984, 1987; Hill et al, 1985; Bird-David, 1992; Kelly, 1995, pp15–23). Seeking to rehabilitate the concept, Binford (1978) and Cohen (1977) addressed some of these issues, while James Woodburn's introduction of the distinction between immediate- and delayed-return societies (1982) helped to account for some of the variability in the level of work effort among hunter-gatherers.

A major development in hunter-gatherer research was stimulated by this debate. Struck by the often imprecise data on which arguments about affluence (or its absence) had been based, a group of younger scholars resolved to do better. They adopted from biology models about *optimal foraging* (Charnov, 1976) and attempted to apply these rigorously to the actual foraging behaviours observed among the shrinking number of foraging peoples where it was still possible to observe actual hunting and gathering subsistence. Important work in this area was carried out by a close-knit group of scholars, often collaborating, and variously influenced by sociobiology and other neo-Darwinian approaches: Bailey (1991), Blurton Jones (1983), Hawkes (Hawkes, Hill, and O'Connell, 1982; Hawkes, O'Connell and Blurton Jones, 1989), Hewlett (1991), Hill and Hurtado (1995), Hurtado (Hurtado and Hill, 1990), Kaplan (Kaplan and Hill, 1985), O'Connell (O'Connell and Hawkes, 1981), Eric Smith (1983, 1991), and Winterhalder (1983, 1986). Reviews and summaries of Optimal Foraging Theory are found in Winterhalder and Smith (1981), Smith and Winterhalder (1992), Bettinger (1991) and Kelly (1995). For critiques see Ingold (1992) and Martin (1983).

More classically oriented research on hunter-gatherers attempted to bring together much of the rich historical and ethnographic material that had accumulated since the 1940s. *The Handbook of North American Indians*, under the general editorship of William Sturtevant, chronicled the 500 Nations of the continent in a series of landmark regional volumes. Six of these deal largely if not exclusively with hunting and gathering peoples: *Northwest Coast*, edited by Wayne Suttles (1990); *Subarctic*, edited by June Helm (1981); *The Great Basin*, edited by Warren D'Azevedo (1986); *California*, edited by Robert Heizer (1978); *Arctic*, edited by David Damas (1984); and *Northeast*, edited by Bruce Trigger (1978) (see also Trigger and Washburn 1996). On other continents Barnard (1992b) and Edwards (1987) produced overview volumes on the Khoisan peoples and Aboriginal Australians respectively.

A New Generation of Research

While the optimal foraging researchers based their work on models from biology and the natural sciences, a larger cohort of hunter-gatherer specialists were moving in quite different directions. Drawing on symbolic, interpretive and historical frameworks this group of scholars grounded their studies in the lived experience of foragers and post-foragers seen as encapsulated minorities within nation states, who still strongly adhered to traditional cosmologies and lifeways. Examples include Diane Bell's *Daughters of the Dreaming* (1983), Hugh Brody's *Maps and Dreams* (1981), Julie Cruikshank's *Life Lived like a Story* (1990), Fred Myers' *Pintupi*

Country, Pintupi Self (1986), Elizabeth Povinelli's *Labor's Lot* (1993), and Marjorie Shostak's *Nisa: The Life and Words of a !Kung Woman* (1981).

The Conferences on Hunting and Gathering Societies (CHAGS)

One way of tracking broader trends in hunter-gatherer research is to follow the CHAGS series of conferences through the 1970s, 1980s and 1990s. In 1978 Maurice Godelier convened a Conference on Hunting and Gathering Societies in Paris to observe the tenth anniversary of the publication of *Man the Hunter*. The conference brought together scholars from a dozen countries including the Dean of the Faculty of the University of Yakutia, himself an indigenous Siberian (Leacock and Lee 1982). The conference proved such a success that Laval University offered to host a follow-up conference in Quebec in 1980. Organized by Bernard Saladin d'Anglure and Bernard Arcand, the conference continued the tradition begun in Paris, wherein anyone who wanted to participate could do so as long as they were self-financing. Inuit broadcasters were among the several members of hunter-gatherer societies present.

By now it was becoming clear that a need existed for continuing the series, and Professor I. Eibl-Eibesfeldt of the Max Planck Institute in the Federal Republic of Germany took on the task of organizing CHAGS III. The Munich CHAGS in 1983 was a smaller, by-invitation affair, and the book that resulted reflected one particular school (revisionist) of hunter-gatherer studies (Schrire, 1984). CHAGS IV, held at the London School of Economics in September 1986, returned to the more open policy with a wide range of constituencies represented. The active British organizing committee led by James Woodburn and Tim Ingold along with Alan Barnard, Barbara Bender, Brian Morris and David Riches produced two strong thematically organized volumes of papers from the conference (Ingold et al, 1988a, 1988b).

CHAGS then moved to Australia. Hosted by Les Hiatt of Sydney University, CHAGS V convened in Darwin, capital of the Northern Territory, in August 1988. CHAGS V proved to be a marvellous world showcase for the active community of anthropologists, Aboriginal people, and activists working on indigenous issues in Australia.

Fairbanks, Alaska was the location of CHAGS VI (1990), the first of the CHAGS series to be held in the US since the original 1966 Chicago conference. Convened by the late Linda Ellanna, the Fairbanks conference was memorable for being the first CHAGS at which a large delegation of Russian anthropologists was present, flying in from Provedinya just across the Bering Straits in Chukotka. Indigenous Alaskans played a prominent role in Fairbanks as well (Burch and Ellanna, 1994). CHAGS VII, in Moscow in August 1993, convened by Valeriy Tischkov and organized by Victor Shnirelman at the Russian Academy of Sciences, is discussed below. The international hunter-gatherer community convened for CHAGS VIII, at the National Museum of Ethnology in Osaka, Japan, in October, 1998, with future meetings projected in the new millennium for Scotland, India and southern Africa.

This ongoing series of CHAGS gatherings held on four continents has provided an excellent monitor on the state of hunter-gatherer research in recent decades, and a unique perspective on its increasingly international and cosmopolitan outlook.

While the theoretical debates of the Man the Hunter conference of 1966 had revolved around issues of the evolution of human behaviour, the recent series has moved relatively far from evolutionary and ecological preoccupations. In their stead hunter-gatherer specialists have developed several major foci of inquiry.

At the Moscow CHAGS in August 1993 and at Osaka, 1998, a large and active scholarly contingent focused on foragers in relation to the state; papers on land rights, court battles, bureaucratic domination and media representations documented the struggles of foragers and former foragers for viability and cultural identity in the era of Late Capitalism. Many of the research problematics grew out of close consultation with members of the societies in question. Increasingly it is they who are setting research agendas, and in some cases – Aleuts at Fairbanks, Evenkis at Moscow and Ainu at Osaka – presenting the actual papers. This branch of hunter-gatherer studies is closely aligned with the emerging worldwide movement for recognition of the significance of 'indigenous peoples' and their rights.

The humanistic wing of hunter-gatherer studies has been represented by a major focus at the recent CHAGS on symbolic and spiritual aspects of hunter-gatherer life. Here were found richly textured accounts of forms of consciousness, cosmology and ritual, while other papers dealt with the changing worldviews of foragers under the impact of ideologies of state and marketplace. To showcase the offering of the Moscow CHAGS there is an excellent volume of papers edited by Biesele et al (1999), with an equally rich set of publications planned for Osaka.

One theme unifying these diverse scholars from many countries was that all were able to see in hunter-gatherer society *some* component of historical autonomy and distinctiveness. The notion of 'pristine' hunter-gatherer was nowhere in sight, but neither did anyone argue that the cultural practices or cosmological beliefs observed were simply refractions of dominant outsiders, Soviet or Western. Refreshingly, the 'other's' reality was not considered to be so alien that the ethnographer was incapable of representing it with some coherence.

Another unifying theme was the recognition that change was accelerating, and that the magnitude of the problems faced by these indigenous peoples was enormous, especially those in the Russian North, for whom ecologically destructive socialist industrialization has been followed directly by the advent of get-rich-quick capitalism. Similar conditions were replicated in most of the world's regions where foragers persist.

Hunter-gatherer Studies Today

As humankind approaches the millennium, what are some of the main currents in research about hunter-gatherers, present, past and future? Four principal tendencies can be discerned. These are set out below with two provisos: first, none of these approaches has a monopoly on 'the truth'; each has something to offer and each has its shortcomings. Second, none in practice is air-tight, and many scholars may participate in two or more.

1. *Classic.* The internal dynamics of hunter-gatherer society and ecology continue to interest many scholars. Kinship, social organization, land use, trade, material culture and cosmology provide an ongoing source of ideas, models and analogies for archaeologists and others reconstructing the past. When due account is taken of the historical circumstances, ethnographic analogies can be a valuable tool. Archaeologists are now arguably the largest 'consumers' (and producers) of research on hunting and gathering peoples, even though the opportunities for basic ethnographic research are shrinking rapidly. Robert Kelly's book *The Foraging Spectrum* (1995) is an excellent example of work in the classic tradition (with a minor in behavioural ecology). Tim Ingold has authored several works which sought to integrate the social and the ecological through an application of neo-Marxist theory (1986), and Ernest Burch Jr. continues to produce meticulous ethnographies on arctic Alaska and Canada in the classic tradition (e.g. Burch, 1998). Theorists *beyond* anthropology continue to turn to the hunter-gatherer evidence in constructing their own models about economics or gender roles or cosmology or many other subjects where a basic human substrate is sought. The results are highly variable.
2. *Adaptationist.* Discussed above, the second 'tendency' is the area of behavioural ecology and Optimal Foraging Theory, with a strong presence in the US, particularly at the Universities of Utah and New Mexico. The adaptationists are the prime advocates of a strictly 'scientific' paradigm within hunter-gatherer studies and this places them, to a degree, at odds with others in the field for whom humanistic and political economic approaches are primary (cf. Lee, 1992). While some behavioural ecologists approach issues of demography and subsistence from a historically contextualized position, a significant number continue to march under the banner of neo-Darwinian sociobiology. And while some acknowledge the impact of outside forces – such as dam construction, logging, mining, rainforest destruction, bureaucracies, missionaries and land alienation – on the people they study, others focus narrowly on quantitative models of foraging behaviours as if these existed in isolation. In addition to criticizing their science, critics of this school have argued that by treating foragers primarily as raw material for model building, the behavioural ecologists fail to acknowledge foragers' humanity and agency, as conscious actors living through tough times and facing the same challenges as the rest of the planet's beleaguered inhabitants. Having fought to maintain their scientific rigour as

anthropology-at-large moves in a more humanistic direction, the challenge for the behavioural ecologists now is to make their work also relevant and useful to their subjects in their fight for cultural, economic and ecological survival. Within the field of behavioural ecology of hunter-gatherers, and in relation to the terms of this field, Kristen Hawkes has been the most articulate spokesperson, while Hill and Hurtado (1995) and Smith and Winterhalder (1992) offer some of the best recent work.

3. *Revisionist*. This school of thought argues that the peoples known as 'hunter-gatherers' are something quite different: primarily ragged remnants of past ways of life largely transformed by subordination to stronger peoples and the steamroller of modernity. Two of the principal authors of this view are Schrire (1984) and Wilmsen (1989). Although the evidence presented in this volume challenges this thesis at a fundamental level, the 'revisionists' do raise serious questions. For too long students of hunter-gatherers and other pre-state societies tended to treat in isolation the peoples they researched, regarding them as unmediated visions of the past. Today history looms much larger in these studies. Hunter-gatherers arrive at their present condition by a variety of pathways. By acknowledging this fact and being sensitive to the impact of the wider political economy, the authors of this volume are responding to the challenges made by the revisionists. Beside the archaeological and historical evidence contra the revisionist position, the most eloquent testimony in the revisionist debate is the voices of the people, setting out their ongoing sense of themselves as *historically rooted* peoples with a tradition and identity as hunters and gatherers. Their eloquence, resilience and strength demonstrate that even in this hardbitten age of 'globalization' other ways of being are possible.
4. *Indigenist*. This fourth perspective brings the people studied, their goals and aspirations, firmly into the centre of the scholarly equation. For many of the authors in this book the indigenist perspective represents the outcome of a long search for an anthropology of engagement that is also scientifically responsible. The long revolution in the ethics of anthropology has come to the present conjuncture in which the still-legitimate goals of careful scholarship must he situated *in tandem with ethical responsibilities* to the subjects of inquiry. This involves at the very least attempting to account for the forces impacting on peoples' lives in ways that valorize their choices and give them useful tools to work with.

For example, in the volume *Cash, Commoditization, and Changing Foragers* (1991), co-edited with Toshio Matsuyama, Nicolas Peterson offers a coherent framework for understanding the complex impacts of the market economy on the internal dynamics of foraging peoples. This issue has tended to polarize the field of hunter-gatherer studies into two camps: the revisionists who see capitalism as having long ago destroyed the foraging economy, and the 'pristinists' who deny or minimize these effects. Peterson's subtle and insightful analysis succeeds in bridging these two entrenched positions and showing areas of common ground. The market and the welfare state, in Peterson's view, have altered but not destroyed foraging economies; in many cases the impacts have been absorbed and put to use in reproducing forager communities and identity *within* the wider society. A similarly lucid and original analysis underlies Peterson's re-analysis of the subject of sharing and gift-giving (1993). He focuses on the ways in which sharing reproduces core values within foraging communities, enabling them to maintain independent identity in spite of the vastly greater power and reach of the enveloping market-based society.

Researchers in the indigenist perspective must perform a difficult balancing act: how to combine advocacy and good rigorous scholarship, without subsuming ethical obligations of the scholar to political expediency (or vice versa).

In addition to a number of authors in this volume, the 'indigenist' perspective on hunter-gatherers is evident in the work of such scholars as Eugene Hunn (1990), Joe Jorgensen (1990), Basil Sansom (1980), Janet Siskind (1980) and Polly Wiessner (1982).

Given the growing political visibility of modern foragers within their respective nationstates and the worldwide movement for indigenous rights, recent research has been based increasingly on agendas arising from within the communities themselves. Land claims, social disintegration, substance abuse and the concomitant movements to reconstitute 'traditional' culture and revitalize institutions have become central concerns.

About the *Cambridge Encyclopedia of Hunters and Gatherers*

Part I is arranged into seven sections, based on the world's principal geographical regions. Each is introduced by an overview of the region's foraging peoples by the regional editor, followed by an essay on the area's prehistory. The heart of the *Encyclopedia* is the individual case studies of the history, ethnography and current status of over 50 of the world's best-documented hunter-gatherer groups. The goal here is to present a balanced account that includes both the traditional culture and social forms, and the contemporary circumstances and organization for resistance. Authors were chosen not only for their expertise as authorities but also for the contributions they have made as advocates for the well-being of the people they write about. Each chapter also contains a sidebar in which members of the society speak to the reader in direct quotations.

Part II contains thematic essays covering a broad array of topics: from mythology, religion, nutrition, gender and social life, to experience at the hands of colonial forces and status in contemporary states and human rights. Other essays address the traditional and contemporary music of hunter-gatherers on the 'World-beat' scene, and their current position in world art markets where works by aboriginal artists may fetch four and five figures. These essays thus situate the hunting and gathering peoples not only in their own world but also in the wider world's political economy and the emerging global culture.

The Regions

1 North America (regional editor: Harvey A. Feit; archaeological background: Aubrey Cannon)

Prior to colonization about two-thirds of North America was occupied by hunters and gatherers, including most of what is now Canada and much of the US west of the Mississippi. Some of the best-known recent foragers reported in the *Encyclopedia* include the James Bay Cree (Feit) and Labrador Innu (Mailhot), the Subarctic Dene in western Canada and Alaska (Asch and Smith), and the Inuit (Eskimo) of Arctic Canada (Burch and Csonka) and Alaska (Worl). The foragers of the Great Basin are represented by the Timbisha Shoshone of Nevada (Fowler). The mounted hunters of the Plains and intermontane West represent a successful secondary adaptation to big-game hunting by former farmers and foragers after the arrival of the horse in the 17th century (Kehoe). Complex foraging societies, with slavery and rank distinctions, occupied all of the west coast of North America from California to the Alaskan panhandle (Daly).

2 South America (regional editor: Laura M. Rival; archaeological background: Anna C. Roosevelt)

The southern cone of the South American continent was occupied by foragers including, at the extreme south, the Ona, Yamana and Selknam of Tierra del Fuego (Vidal) and the Toba of the western Chaco (Gordillo). Some of the hunters of the southern cone became mounted hunters with the arrival of the horse, paralleling processes in North America. The numerous peoples of the Amazon and Orinoco basins combined foraging with shifting horticulture, with some like the Equadorean Huaorani (Rival) relying largely, and a few peoples like the Cuiva of Venezuela (Arcand) almost entirely, on foraging. South American foragers like the Sirionó (Balée) show evidence of having been more reliant on farming in the past. The Paraguayan Aché (Hill and Hurtado) are well known in anthropological circles for the detailed behavioural ecological studies made about them.

3 North Eurasia (regional editors: Victor A. Shnirelman and David G. Anderson, with Bruce Grant; archaeological background: Victor A. Shnirelman)

In northern Siberia and the Russian Far East a number of hunter-gatherer groups exist, combining foraging with small-scale reindeer herding. These groups vary widely in the timing of colonial encounter (some being reached only in the late 19th century), and in the degree to which they have suffered from the industrialization of the Soviet period. Notable among those who were primarily foragers are the Khanti (Nemysova, with Bartels and Bartels), Nia/Nganasan (Golovnev), Iukagir (Ivanov), Ket (Alekseenko), and the Chukchi and Siberian Yupik (Schweitzer), the latter close relatives of the Alaskan Eskimo. The Evenki of central Siberia (Anderson) and the Nivkh of Sakhalin Island (Grant) have been particularly hard hit by industrial pollution and the break-up of the Soviet Union. In addition Svensson discusses the well-known Ainu culture of Hokkaido, Sakhalin and the Kurile Islands.

4 Africa (regional editor: Robert K. Hitchcock; archaeological background: Peter Robertshaw)

Although most of the continent pre-colonially was occupied by farmers, herders and agrarian states, Africa was home to several well-known foraging peoples. The Pygmies occupy the equatorial rainforest in a broad belt across central Africa from Cameroon to Rwanda, represented in the volume by the Mbuti of the Congolese Ituri Forest (Ichikawa) and the Aka of the Central African Republic (Bahuchet). In East Africa the Hadza of Tanzania (Kaare and Woodburn) have remained staunchly independent of neighbouring farmer-herders, while the Okiek of Kenya (Kratz) have long-established trade relations with the Maasai. In the Kalahari Desert of Botswana, Namibia and Angola live the well-known San or Bushmen peoples. Some, like the Ju/'hoansi (Biesele and Kxao Royal-/O/oo) and the central Kalahari/Gui of Botswana (Tanaka and Sugawara), remained relatively autonomous until recently; others like the Tyua of eastern Botswana (Hitchcock) have a long history of close contact. The Mikea of south-eastern Madagascar became foragers in the 19th century, adopting the relative security of forest hunting and gathering during a period of instability and warfare (Kelly et al).

5 South Asia (regional editor: Nurit Bird-David; archaeological background: Kathleen Morrison)

In this region of ancient civilizations a surprising number of foragers exist, occupying upland forested areas and providing forest products (honey, medicinal herbs, furs) to lowland markets. It is this economic niche presumably that has allowed the South Asian hunter-gatherers to persist to the present and remain viable. Examples include the Wanniyala-aetto (Veddah) of Sri Lanka (Stegeborn), the Nayaka of Kerala (Bird-David), the Paliyan (Gardner), and the Hill Pandaram (Morris) in the southern tip of the subcontinent, and the Birhor (Adhikary) and Chenchu (Turin) in central and eastern India. Most famous are the Andamanese, occupying a series of islands in the Bay of Bengal, who remained isolated into the late 19th century and in one case well into the 20th (Pandya).

6 South-east Asia (regional editor: Kirk Endicott; archaeological background: Peter Bellwood)

Orang Asli is a cover term for the indigenous non-agricultural peoples of the Malay peninsula and insular South-east Asia. Among the best known are the Batek (Endicott) and Jahai (Van der Sluys) in the Malaysian forest and the Batak (Eder) on the Philippine island of Palawan. Other groups are found in Thailand, Myanmar, Laos and China's Yunnan province (Song and Shen). On the island of Borneo live the Penan of Sarawak (Brosius), firmly rooted in hunting and gathering until recent displacement by multinational logging interests. The Philippine main islands have several pockets of foraging peoples, including the Agta of northeastern Luzon famous for their female hunters (Griffin and Griffin).

7 Australia (regional editor: Nicolas Peterson; archaeological background: Michael A. Smith)

Prior to European colonization in the late 18th century, Australia was entirely occupied by hunting and gathering peoples. These suffered a precipitous decline after 1788. Nevertheless in the centre, north and west, Aboriginal people have persisted, the last nomadic Pintupi foragers in the Western Desert coming in to settlements in the 1950s and 1960s (Myers). Arnhem Land Aborigines such as the Yolngu (Keen) retain significant elements of social and ritual organization, as do some of the desert groups like the Warlpiri (Dussart), Pintupi (Myers), and Arrernte (Arunta) (Morton). The Aborigines of Cape York in north-east Queensland (Martin) and the Kimberleys (Toussaint) and the famous Tiwi of Bathurst and Melville Islands (Goodale) give a sense of the range of variation among contemporary Aboriginal peoples. A significant percentage of Aborigines are urbanized and, like the Ngarrindjeri in South Australia (Tonkinson), are struggling to preserve and revivify their cultures and land rights in the face of the indifference and tokenism of Australian society at large. The Torres Strait Islanders (Beckett) lie geographically and culturally midway between Australia and Papua New Guinea. They are active partners with Aborigines in political movements, legal challenges, and administrative structures.

Although the main story of hunters and gatherers today is carried by the 53 case studies and their regional introductions, important themes cross-cut the focus on regions and cultures. The special topic essays focus attention on broader issues involving or affecting hunting and gathering peoples worldwide.

Alan Barnard traces the complex perceptions (and misperceptions) of hunter-gatherers through Western intellectual history. As noted above, Barnard sensitizes us to the fact that foragers have always been viewed through a thick lens of ideology and this became even more pronounced when European colonialism and its oppositions became predominant sites of political and cultural discourse about foragers. Barnard documents how current debates are actually reprises of older controversies resurfacing anew.

Andrew Smith follows with a magisterial survey of the world prehistory of hunting and gathering peoples. Smith notes that for much of human history hunting and gathering was the universal mode of life. His overview offers a sense of the world-historical events that led first to the 2 million year ascendancy and then the eclipse of hunting and gathering as, continent by continent, farmers, herders and states arose, ultimately to marginalize and encapsulate the foraging world.

John Gowdy represents a refreshing incursion by a sister discipline to the world of hunter-gatherers. An economist, Gowdy makes good use of hunter-gatherer materials to take a sharp look at the conventional wisdom economists (and the rest of us) live by. Gowdy questions in turn the economic concepts of scarcity, production, distribution, ownership and capital and in each instance counterposes alternative examples from the hunter-gatherer literature. Following on Marshall Sahlins' pioneering work (1968, 1972), Gowdy portrays these economic core concepts more accurately as culturally bound constructions specific to a time and place and not eternal expression of basic human nature. These themes are developed in greater depth in Gowdy (1998).

For over 20 years Tim Ingold has been reflecting on hunting and gathering as a way of life, a mode of production and an ecological adaptation. Here he brings these lines of inquiry together to ponder the nature of hunter-gatherer sociality. Ingold asks whether hunter-gatherers, living in direct, face-to-face groupings, do not exhibit a form of sociality of a qualitatively different nature from that of the rest of humanity, living in hierarchical, often anonymous, often alienated circumstances. After reviewing theories of the patrilocal band and of 'primitive communism' Ingold then draws out some of the profound implications of this line of inquiry for social theory more generally.

The second group of special essays surveys six major aspects of hunter-gatherer life in cross-cultural perspective. Karen Endicott addresses the large ethnographic and critical literature about gender in hunting and gathering societies. Noting the persistent male bias of older ethnographies that pushed women to the margins, Endicott discusses a number of recent studies that rectify this misperception. Women's roles in subsistence, kinship and politics are explored. Drawing on her own familiarity with South-east Asian foragers, Endicott considers the well-known views of Eleanor Leacock about women in foraging societies (1978, 1982) in opposing the doctrine of universal female subordination.

Catherine Fowler and Nancy Turner discuss Traditional Ecological Knowledge (TEK). Hunter-gatherers are notable for the intensity of their spirituality and connection to the land, a connection further intensified by the experience of dispossession. Fowler and Turner show how, among hunter-gatherers, systems in the natural world are incorporated into the spiritual and social worlds. 'Particularly important', in their view, 'is the sense of place and purpose communicated by the oral tradition, and the cumulative wisdom derived from knowledge of complex ecological relationships.' The authors point to the negative consequences of breaking this connection, leading to loss of purpose, language and culture. They also speak of groups in which the connection to land and foraging is being recaptured.

Mathias Guenther presents a rich account of the intellectual and spiritual world of hunter-gatherers, a vast continent of myth and practice that is a major world-historic heritage. While Fowler and Turner show how Nature is an encyclopedia of practical knowledge, Guenther views the cosmologies of foraging peoples as wellsprings of supernatural and ontological meanings. He explores the ubiquity of the Trickster figure in world mythology and traces the anthropological history of shamanism from its first documentation in eastern Siberia in the late 19th century to its recognition as a religious phenomenon found in every continent. Guenther also documents the successful adaptation of some shamanistic methods into healing practices of contemporary medicine.

In an original synthesis Victor Barac explores the world of hunter-gatherer music. Presenting examples from Africa, Australia and North America, Barac documents the core features of this genre and its points of difference from the musics of non-foraging peoples. He then gives an account of the extraordinary impact made by hunting and gathering musicians and singers upon the 'Worldbeat' and pop music scenes. In examples ranging from the Australian Aboriginal group Yothu Yindi to the Canadian Inuit artist Susan Aglukark, Barac documents the unique interweaving in the music of these artists of traditional elements along with profound reflections on contemporary themes of poverty, violence, racism and loss.

Howard Morphy follows with an overview of the art of hunting and gathering peoples. He first notes variation in artistic production and the wide variance in the permanence of this art – from body and sand painting which lasts a day to rock art lasting millennia. Morphy traces three cases of hunter-gatherer art which have reached world status: North-west Coast art, Aboriginal Australian bark paintings, and Inuit soapstone carvings. Each has enjoyed extraordinary success on international art markets, as well as becoming part of the iconography of their respective nationstates.

One of the recurrent themes in hunter-gatherer research is the surprisingly good nutritional status of foraging peoples. As S. Boyd Eaton and Stanley Eaton point out, there are many lessons to be learned from the study of foragers' diet and exercise regime. In the precolonial period foragers led healthy outdoor lives with a diet consisting entirely of 'natural' foods. Salt intake and refined carbohydrate consumption were low and obesity rare, as were many of the diseases associated with high-stress sedentary urban living such as diabetes, heart disease and stroke. While infectious diseases took their toll, some of these were evidently introduced during the colonial period well before the colonists themselves arrived in local areas.

One of the strangest episodes in the history of hunter-gatherer studies began in 1972 when a Philippine-American team reported finding a 'Stone Age people' who were claimed to have been living in caves on a diet of wild foods out of touch with the rest of the world for over 500 years! The Tasaday, as they came to be known, became world-famous, featured in international media and in several *National Geographic* specials. Despite the public's acceptance, nagging doubts remained among scholars about the authenticity of such a seemingly far-fetched story. Gerald Berreman traces the history of the Tasaday from the beginning and reveals it as an elaborate hoax, probably the biggest anthropological hoax since the Piltdown fraud. With painstaking detail Berreman invites the reader to evaluate the evidence in what has become a fascinating detective story of greed in high places and otherwise blameless indigenous people drawn in as accomplices.

John Bodley chronicles the complex history of the encounter between hunting and gathering peoples and European colonialism. In the 500 years of European incursions into the rest of the world, band and village societies faced insurmountable odds and many succumbed to a combination of military predation, land loss and the effects of introduced diseases. Yet despite the horrors of the colonial period, a surprising number of foragers survived and are present to witness the dawn of the third millennium. Bodley documents the tenacity and ingenuity of these survivors and how they combined resistance and accommodation to preserve a way of life they valued.

As long as they had the frontier, hunting and gathering peoples could survive by moving beyond the reach of the colonial authorities. But with the arrival of the modern nationstate, administrative structures reached everywhere. David Trigger surveys the ways in which states of the First, Second and Third Worlds first pacified and censused and then divided and ruled foraging peoples, attempting to make them conform to the role of 'good citizens'. Trigger offers important insights into the lived realities of foragers and post-foragers today as they adjust to bureaucratic domination. He notes significant differences between the situation of former foragers in the Western capitalist states, and those in the developing world and the former USSR.

In the last chapter, Robert Hitchcock surveys the state of human rights for indigenous peoples. Given their new status as 'wards' of states, foragers have undergone transformations in political consciousness. Foragers are increasingly coming to see themselves as encapsulated minorities, as ethnic groups, and as stakeholders within the civil societies of states. At a broader level they are coming to see themselves as part of the larger global community of indigenous peoples. Indigenous peoples now are a force on the world stage, but despite the UN's declaration of the period 1995–2004 as the 'Decade of Indigenous Peoples' the human rights of many continue to be abridged, violated and denied, Hitchcock surveys the complex terrain on which foragers and post-foragers make claims on the political agendas of states and international organizations. Hitchcock appends a useful up-to-date list of over 50 indigenous organizations and advocacy groups.

An Afterword

These 14 essays and the case studies that precede them convey a sense of what makes present-day hunters and gatherers so intriguing. Long the subject of myth and misconception, the hunting and gathering peoples have come into focus in recent years. Far from being simply the cast-offs of creation or victims of history, the foraging peoples have become political actors in their own right, mounting land claims cases, participating in the environmental movement, and lobbying for their rights with governments and the UN. Also they are being sought out by spiritual pilgrims from urban industrial societies seeking to recapture wholeness from an increasingly fragmented and alienated modernity.

As humanity marks the new millennium, there is an increasing preoccupation with where we have come from and where we are going. The accelerating pace of change and the ceaseless transformations brought about by economic forces have had the effect of obliterating history, creating a deepening spiritual malaise. For centuries philosophers have sought the answers to humanity's multiple problems in the search for the holy grail of 'natural man', the search for our ancestors. *The Cambridge Encyclopedia of Hunters and Gatherers* does not offer simple or pat answers to the questions of the social philosophers. Yet it is our hope that in the documentation of foragers' history, culture and current situation, readers will find a rich source of ideas, concepts and alternatives to fuel the political imagination.

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3

Mind

H. Brody

1

In 1973, after a year in the Arctic, early one morning I visited Anaviapik's house in Pond Inlet. Anaviapik and Ulajuk were at their small kitchen table, drinking tea. Everyone else was asleep. I went in, helped myself to a mug and sat down with them. As always, they said how pleased they were to be visited. '*Pulartiarit*,' said Anaviapik, meaning literally 'Visit well,' 'Be welcome.' Then he asked: '*Isumassaqarpit*?' 'Do you have the material for thought?', meaning 'Is there something on your mind?' 'No,' I said. 'I'm just visiting.'

'That's good,' said Anaviapik, 'because I have a thought, and I have a question for you.'

His question, which seemed to arise from a conversation that he and Ulajuk had been having just before I came into their house, was this: '*Qanuingmat tassumanik Qallunaat isumaqattalaursimajuit Inunnit isumarqanigitunit iila isumarqijugut Inuulluta? Taima isumangmata tusaumavit?*' 'How is it that in the old days the Qallunaat always thought that the Inuit had no thoughts and that we Inuit were mindless? Is that what you have heard?'

As I thought about what to say, Ulajuk and Anaviapik smiled at me. Then both of them burst out laughing. I recognized their laughter as a way of removing any possible risk that they might sound aggressive. This was just a question, a puzzle, something they wanted to talk to me about.

2

In 1979, late in the year but before the snows had come, I arrived in Fort St. John to discover that Thomas Hunter, the Dunne-za elder, was in hospital. Thomas was now in his eighties, a small, tough man whose face had become a maze of wrinkles but whose hands were still strong and whose eyes were still bright with curiosity

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and ideas. He had been ill for a while, coughing a great deal and suffering periods of sudden weakness.

A few weeks earlier, Thomas's family, along with several others, had moved from the Halfway River Reserve to a moose-hunting area a few miles to the north. There they had been preparing dry meat. Moose were plentiful, and the hunters had killed several. The meat had been brought back to the family tents for the women to slice into long, paper-thin sheets. They hung these on wooden frames beside fires, where the meat part dried and part smoked. After a few days, the slices were almost weightless and perfectly preserved. They were a source of concentrated protein that could be stored for many months and packed into bags that were easy to carry. Thomas had not gone to the dry-meat camp that year. He had become very weak; before the others left, he had been taken to the Fort St. John hospital.

I found him lying on his bed in a small public ward, dressed in jeans and a vest. As soon as he saw me, he said, as he had so often before when I arrived back in Dunne-za country: 'I know you here. Time to hunt. We better go someplace, look for moose.' I thought he was making a joke, then realized he was serious. 'But can you leave the hospital?' I asked. 'You see doctor,' said Thomas. 'Then we go to dry-meat camp.'

Thomas's English was fluent, but it came from his fur-trading days. He used it to make direct statements or to ask straightforward questions. His real language was Dunne-za Athabaskan. So we did not have a discussion about just how he was going to manage in the camp. He had made himself clear, and I went to find his doctor.

The doctor was a tall young man in a hurry. He said that Thomas was very sick. His lungs were 'gone'. I asked what the actual diagnosis was. 'TB,' he said. 'Maybe cancer as well.' He paused, then added: 'Nothing we can do.' So was it all right to take him out of the hospital? 'Fine,' said the doctor. 'I just hope that you take him somewhere he can get some care.' Were there medicines I should take with us? Was there any treatment he should come back to the hospital for? The doctor shrugged. 'There's nothing much anyone can do,' he said. 'He's old and his lungs are gone.' I could take Thomas whenever he wanted to go.

I was upset. There was a certain callousness about the way the diagnosis had been given, and something eerie about the lack of medical prescription. Was Thomas about to die? I went back to Thomas's bed and sat down beside him. He looked at me. He must have known that I had seen the doctor. He didn't say anything. I looked at his eyes, which seemed to have sunk back into his skull. He had lost weight. 'The doctor says you can leave here when you want. But I guess you could stay, too, if that seemed better.' I paused. 'You would be cared for here.'

Thomas did not hesitate. 'Okay we leave now?' 'Yes,' I said. 'When you want.'

'Now,' he said. He sat up on his bed, swung his legs over the side and stood up. We found his shoes and jacket and walked out.

Thomas wanted to go straight to the dry-meat camp. He did not say much, and I noticed that he was breathing with some difficulty. I was worried. Maybe we should go to the reserve, where he would have a bed and be within a few hundred yards of the clinic; at least we would have access to a phone. He could call for emergency help if he needed it, or see the nurse who came each week. No, said Thomas, he wanted to be in the camp.

When we got to the camp, everyone else was away. I asked Thomas again if he would like to go to the reserve, at least to find other members of his family. 'No,' he said. 'Better finish here.' He went to his family's tent and sat down at its entrance. He was tired and weak. I made a fire for him and put a kettle on to boil. I fetched a few pieces of dry meat so that he could eat whenever he was hungry. He sat very still, looking around, not saying much.

As the fire blazed up and the kettle began to steam, Thomas said: 'See the horses.' I looked up and saw that the family's horses were all standing close to the little group of tents. They had their heads low to the ground and seemed to be staring at us. I was astonished: the horses always kept their distance from the camp, moving far into the forest, doing their best not to be caught and ridden or loaded with packs. Every morning they had to be trailed into the woods and, often with some difficulty, herded back to the tents, where they could be tethered for use. Now they stood there, close, unmoving.

'Horses they know,' he said. 'In my mind.'

I waited for a while, making sure Thomas got his tea and was comfortable. The horses stayed there, watching. Thomas died a few weeks later.

3

In 1988, during the filming of *Hunters and Bombers*, we interviewed Mary Adele Andrew, the mother of Alex Andrew, my Innu guide and interpreter. She was a large, energetic woman who had brought up a big family as a single parent – her husband had died when the children were still young. She had a strong inner warmth, a generosity of spirit that insisted anyone who came to her house must sit and eat whatever she happened to be cooking. I had been with her at a summer camp, and I knew how much she loved to be far away from the settlement, out on the land. I knew she would have a great deal to say about what had happened to her family, and to all the Innu she knew, as a result of having spent so much time stuck in Sheshashiu.

Mary Adele sat at her kitchen table and talked to Alex. She spoke slowly, carefully, with great force. 'These houses were built to trap us,' she said. 'They told us, "Stay here, you'll get a house." But it was a trick to get our children to go to school and to make sure we stayed in one place. It was a lie, so we wouldn't see our land being destroyed. They hoped we wouldn't say anything. They said when our children leave school, they'll get good jobs. But nothing happened.'

Instead, the people had lost their real wealth, their real homes. Their land had been taken. The Church and the school, the priests and the government, had joined forces to do this. In one of our interviews, Elisabeth Penashue told us: 'In the old days we used to revere the priests. They were powerful and said, "Don't go out on the land. Send the kids to school or you will lose your family allowance." Parents were afraid. They made the children go to school. When a priest told us to do something, we did it. We listened to him as if he was Jesus.'

In defiance of these intense pressures, Mary Adele Andrew and Elisabeth Penashue, as well as some others, continued to spend as much time as they possibly could on their lands with their families. They were teaching the young how to live there, as Innu. It had been hard, and some had lost a great deal, but there was hope – so long as they could keep going onto the land.

One day at a summer camp, where the women were baking bread in ovens they had scooped out of sand heated with large fires of driftwood, Mary Adele said: 'On the land we are ourselves. In the settlement we are lost. That was the way they made our minds weak.'

4

European 'discovery' of the New World, those great adventures to the Americas as well as to southern Africa and Australasia, led to a set of theories about the peoples who lived in these lands. The theories, which disregarded hunter-gatherer economic systems, languages and belief, were underpinned by the idea that hunter-gatherers were not quite human beings at all.[1]

Articulate colonists of southern Africa in the 16th century declared that the Khoisan peoples they encountered at the Cape of Good Hope were 'the very reverse of humankind … so that if there's any medium between a rational animal and a beast, the Hotantot [*sic*] lays the fairest claim to that species.' In Australia, Aborigines were classified as being at a midpoint on the evolutionary ladder, more a species of animal than human. When William Lanney, the last Aborigine of Tasmania, died in 1869, a struggle to get possession of his bones was fuelled by the belief that 'he represented a last living link between man and ape'.

In 16th-century Spain, the question arose as to whether or not the original inhabitants of the colonies in the Americas were 'natural slaves'. The notion came from Aristotle, whom the Spanish monk Juan Gines de Sepulveda relied on for judging the rights of 'the Indians'. A 'natural slave', according to Sepulveda's interpretation of Aristotle, was a person whose inferiority and ignorance were such that only through servitude could the necessary human development be achieved. In Aristotle, this idea arose as part of a justification of slavery in Greek society; he sought to show that the slave's opportunity to work in the master's household was a chance to experience and learn the arts of civilization. Applying this to Spanish colonial rule, Sepulveda saw slavery as a necessary opportunity. The enslavement of the Indians of the newly conquered territories in South America, who lived far beyond Christian influence and teaching, was 'natural' – and it would bring them into the 'natural' joys and benedictions of the Christian Church. But slaves did not have the right to own property; those who did the enslaving had the right to take all the land and compel its former inhabitants to work for them.

Had it not been for King Philip of Spain, this quasi-Aristotelian justification for the dispossession of South American Indian peoples would have been long forgotten, a small footnote in colonial rationalizations of conquest and theft. In 1550, alerted by his legal experts to disagreements about the question of Indian rights to their lands, the Spanish king authorized a formal public inquiry – the first Royal Commission to deal with indigenous peoples. The inquiry took the form of a debate. On the one side was Sepulveda, very much the theorist: he had never set foot in the new colonies. He advanced the idea that these new peoples were 'natural slaves' and therefore had no rights that could restrict the claims of Spain's conquerors and settlers. The other side of the argument was entrusted to Bartolomé de Las Casas, a monk who had spent 30 years in South America and lived close to indigenous peoples there. He had been among agricultural, imperial societies – not the hunter-gatherers of Amazonia – and he had been surprised by complex and, in many ways, familiar kinds of social institutions. Las Casas had written extensively about his experiences, arguing that the Indians of the colonies had systems of law and administration, as well as ideas of property and morality, that should be respected. The debate lasted almost two years; the king of Spain then took 18 years to decide which argument he would accept. In 1568 he gave his support to Las Casas's point of view. Meanwhile, of course, Spanish policy and practice had been ruthless: Indians were deemed to have neither land rights nor souls. Some were enslaved, many were killed, and their lands were appropriated. Neither the sophistication of the Indians Las Casas described nor the vigour of the public debate in Seville moderated the conviction, shared by colonists and Christian missionaries alike, that these people had not yet reached the evolutionary level of real human beings.[2]

On the settlement frontiers of the North American colonies, the question of the Indians' humanity was also raised. If the indigenous occupants of the lands to which settlers were moving were not humans, but roamed, rather, 'as beasts of the field', then they had no right to resist the new Americans' 'manifest destiny' to take and use all new-found lands.

It is easy to see that an insistence on people's being something other than, or less than, human has been inseparable from the wish to occupy their lands. Doubts about an unquestionable right to appropriate land did effect some challenge to the theory of colonial expansion: legal justifications were sought to defend claims to new territories. At the frontiers themselves, however, colonists at times killed hunter-gatherers as if they were animals. Colonial governments licensed these murders by turning a blind eye, sometimes even condoning them as a suitable response to the 'primitives' and 'savages', whose want of humanity made them a threat to settlement. History records Aborigine hunts in Australia, the killings of Bushman families throughout southern Africa, attacks on the tribes of Amazonia, and relentless campaigns against the Indians of the American West. Early in the 19th century, the philosopher Hegel observed that the development of the American West had cost some 2 million Indian lives – an outcome he deemed to be a necessary part of progress.

5

The assertion that some humans are not human – or are not human enough to have rights – is absurd as well as brutal.

The Spanish *conquistadores* destroyed communities with elaborate agricultural and urban systems. They insisted that the Aztec were barbarous and undeserving of compassion, for they practised human sacrifice and cannibalism. In reality, the Spanish had arrived among people whose material wealth they wanted to plunder. The idea that the victims of this plunder were 'savages' was belied by the very thing the Spanish most wanted from them – the elaborate and magnificent creations of Meso-American artists, including worked silver and fine jewellery.[3]

In reality, explorers and adventurers arrived in the lands of societies that were at least equal to their own. Hunter-gatherers did not display abundant material goods or the technology of warfare, and they did not have the knowledge of mathematics, astronomy, engineering and textiles that was to be found in some indigenous societies of South America. But the Europeans who came ashore from those ships of exploration – dirty, malnourished and ill clad – encountered hunters and gatherers who showed all the signs of being well fed and healthy. The societies of these people were more stable and more secure than those of the explorers; they were also societies in which private and public well-being intertwined to ensure much fairer distribution of resources and greater social justice than the newcomers had ever experienced. But the representatives of 'civilization' did not hesitate to condemn as 'savages' the people who provided the food that kept them alive.

These encounters between unhealthy newcomers and vigorous tribal communities began in the 1400s and continued until the beginning of the 20th century. Another such paradox is to be seen in the history of European ideas. While describing the peoples they were discovering as inferior beings and claiming their lands for themselves, European travellers and intellectuals also began to extol the moral superiority of the peoples who were being conquered, enslaved and dispossessed.

Columbus's description of the very first Carib hunter-gatherers he met includes a recognition that they are 'so generous with all that they possess, that no one would believe it who has not seen it … and [they] display as much love as if they would give their hearts.' Social philosophers made intellectual use of what they saw as life that existed in pure nature. Hobbes's famous reference to life as 'nasty, brutish, and short' came from his imagining a society 'with no place for Industry … no Culture of the Earth … no Arts; no Letters; no Society.'[4] He wrote this in 1650, a critique not so much of the hunter-gatherer world as of the early capitalism of the England in which he lived. In subsequent centuries, philosophers as diverse as Vico, Montesquieu, Rousseau, Hegel, Engels and Marx[5] made use of the idea of a 'natural' human condition both to criticize the societies of their day and to celebrate 'innocence' and 'simplicity' – a core of deep human goodness – in peoples whom we would now call hunter-gatherers. In one context, these newly discovered tribes were savages whose conditions gave them no rights to life, liberty or property. In another, they became symbols for the human potential for goodness, equality and freedom.

These paradoxes point to the cynicism of the colonial project. The explorer Ralph Standish wrote in 1612 about the 'savages' he had met at the Cape of Good Hope.[6] Given their want of human achievements, it was, he said, 'a great pittie that such creatures as they bee should injoy so sweett a country.' The countries of the new worlds were indeed 'sweett' to the farmers who wanted to make them their own. Inca and Aztec silver provided wealth for the impecunious monarchy of 17th-century Spain; extensive grasslands and forest offered at least a hope of wealth to the landless settlers who had reached the expanding edges of European empires. In each place colonists claimed as their own, they concocted justifications for dispossessing people and taking their territories. To say that those they encountered were not human was the most general – and, in its way, the simplest – device for depriving hundreds of cultures and millions of human beings of their rights.

6

When Anaviapik and Ulajuk raised the question of how southerners have seen the Inuit, they expressed a concern that must have puzzled, alarmed and at times oppressed many, if not all, hunter-gatherers. They have experienced the attitudes of settlers and settler governments towards them. They have felt the consequences of the judgement that they, the original inhabitants, are not entitled to their own lands, languages and ways of life. They know that this judgement is somehow connected to a refusal by the colonists to see that hunter-gatherers have minds – a refusal that sits at the centre of the history of colonial misrepresentation.

The indigenous peoples of Canada have been forced to respond to a strong implication in modern legal theory that they do not qualify as fully human. This version of frontier racism has arisen in legal arguments about 'aboriginal title', the rights indigenous peoples may or may not have to their own systems, territories and resources. The legal and political actions that lie behind these contests over title are referred to in Canada as 'land claims'. For a century, various aboriginal peoples have had to make these claims. After his election in 1968, Prime Minister Pierre Elliott Trudeau maintained a long colonial tradition by insisting that the nation's Indians should be assimilated into the mainstream of national life. In 1971, Trudeau announced a change of policy from adamant rejection to circumspect acceptance of a land-claims process.[7] This shift resulted from a judgement in the Supreme Court of Canada in what is known as the Calder case – an action brought by the Nisga'a people, who argued that they had aboriginal title to their territories throughout the Nass Valley. Although the judges were split on the decision 3–3, the message was clear: aboriginal title did, after all, have some legal reality. Since then, arguments over who has which rights have been full of legal complexity. Land claims have at times appeared to define the nation.[8]

The term 'land claim' is itself an anomaly, implying that the onus should be on the original occupants to claim their homes, resources and territories from the colonists. This is a reversal of common sense; the burden of proof should lie with the newcomers. This reverse sense is a first indication of the onerous task indigenous groups have had to undertake. Their elders, historians and lawyers must find ways of satisfying criteria set by the Canadian courts for testing whether or not a claim can indeed be said to amount to a claim to aboriginal title. Litigants from hunter-gatherer and fishing societies have had to prove that:

- they use and occupy a definite territory to the exclusion of all other peoples;
- they have used and occupied the territory 'since time immemorial';
- they are 'an organized society'.

These tests have arisen from accumulated precedents in cases that reach back to the 19th century. But each of the particular requirements for evidence has been confirmed by Canadian courts in the 1970–1990 era. The problems inherent in proving the first two requirements – exclusive use and occupancy – are severe. In many hunter-gatherer systems, there are imprecisions and overlaps of territory that unsettle the demand for boundaries and boundary maintenance that the colonial model requires. For oral cultures to prove continuity of land use beyond the present generation, to the satisfaction of courts that rely above all on first-hand experience and written documents, is also a daunting undertaking. The imposition of legal process and rules on the peoples the colonists have sought to dispossess makes it hard for hunter-gatherers to give evidence of their own kind in their own way. But the difficulties that arise with questions about use and occupation of land do not challenge the hunter-gatherers' humanity. It is in the 'organized society' test that the deepest prejudices reveal themselves.[9]

What are the qualities by which society is judged to be organized? Rules and conventions of behaviour, shared economic practices, common religious beliefs and customs – these things *are* society. To speak of society is to imply organization. People who live without a shared set of values and rules cannot live as a people. The human condition is composed of social realities. And the central indication of this is language.

Language and society are inseparable. Each is a necessary condition for the other. Children who grow up without any form of society do not learn to speak; human societies do not exist without language. The organization of the human mind requires a community of fellows who speak to one another, sharing and thereby teaching the words and rules that constitute the language. We know what words mean because they are used by a group of people to mean things. Society has an existence because it is composed of people who share these meanings and who use them to share everything else that makes human life possible.

To suggest that there are human beings who might live without 'organized society', therefore, is to say that there are human beings who live without society at all. To suggest that a people might live without society is to imply that they are living without language. And to imagine a people without language is to suggest humans who are not quite human.

Think of an elder on the witness stand being quizzed about whether her society is 'organized'. Are there laws? the lawyers ask. Do you have rules about your ways of using land? Do you collaborate? Do you live in anything that we can call a society? To experience this kind of interrogation is to endure scepticism about the obvious. The suggestion is that your people have not lived long on their lands, that they have not lived there in the belief these lands are indeed theirs and no one else's, that they are not attached to these lands in any profound way, and that they do not have customs or beliefs uniquely their own. To answer these kinds of questions is thus to respond to insults. Aboriginal people who take the witness stand in land-claims cases often have an intense feeling of not existing; their history, their homes, the integrity of their grandparents are all contested. To be obliged to prove that which defines you is to have a sense that your very humanity is in question.

7

Imagine the crowded, roaring bar of the George on 96th Street, Edmonton, a Prairie city in the Canadian midwest. The George is a rundown beer parlour in a part of town where no one goes. No one, that is, except drifters, down-and-outs and hard drinkers. There are Indians, some hookers, winos from many backgrounds. It is a place to have friends who don't ask questions, providing warmth that has nothing to do with family or home and a chance to lose any sense of weakness. The tables are crowded; the noise is a shrill mixture of shrieking laughter and shouted conversation; fights break out. A tough place. But for all its toughness, the men and women who come here are far more often generous to one another than they are belligerent. Everyone has almost nothing; people give out drinks, cigarettes, small change and advice about where to bum a hot meal. Everyone belongs because they have all chosen, for a while at least – maybe a week or maybe a year – to belong nowhere.

I went to the George every day for a few months in the spring and summer of 1969. It was my first fieldwork in Canada and my first encounter, therefore, with 'Indians'. In this and other bars, on street corners, in abandoned shacks and at the edges of a park, I talked and drank and laughed with men and women whose lives reached into the Plains of the Midwest, to the Pacific Coast and to the forests of the Subarctic. They spoke to me of spending time 'in the bush', away from 'the white man'. Sometimes, at night, when a slight drunkenness had not yet given way to incoherence, when sadness rather than defiance or humour was the mood of the moment, a few of those I knew best would tell me they would soon be heading home. But I was never sure what home meant or just how many of them would be able to get there.

One of the first people I met in Edmonton was Harry. A tall, heavily built man of about 50, with the strong features of a Plains Indian, he was leaning on the wall outside the George, playing a harmonica. The music was beautiful – a bubbling of sounds, fast and rich, with a blend of tunes that I learned later was part Scottish and part Cree. It was the music of the fur trade, of the encounter between those who manned the trading posts and bought the furs and those who trapped and sold them. I stopped to listen. Harry watched me as he played, then paused and asked if I had a quarter to spare. 'Sure,' I said. I handed him 50 cents. He looked at the two coins, as if measuring their possibilities. 'Good,' he said. 'Now you and me can go buy a few beers.'

Harry became my best friend on skid row. He was a good friend to have. Everyone knew him, and many took pride in his musical skill. He played the fiddle as well as the harmonica, and knew where he could go to find both cups of tea and instruments that he could borrow. He made money by busking on street corners, but only enough to fund more rounds of beer and the occasional bottle of cheap sherry. I suppose he was an alcoholic, but he never got rotten drunk, and he somehow placed himself at a distance from those who did. He was courteous and helpful, and a bit of a street-person social worker: he would take care of those who were most destitute, and he did what he could to prevent fights from drawing real blood.

One Sunday, when the bars were closed and the skid row community broke into little clusters of people on street corners and vacant lots, Harry told me to come and hear some real music. He took me to a bootlegger who sold us a bottle of the cheapest sherry, then led me to an abandoned house a few blocks from the George. It appeared to be boarded up. But Harry knew a way in through a broken door to its basement. Down there, in the gloom, a group of men and women sat in a circle. A few bottles stood around, and one man was unconscious in a corner.

We joined the group. No one said much, and then two or three people began to sing. Then another few people; a different song. It was Algonquian music, with drumbeat rhythms tapped out on a broken chair and the floor, the voices high-pitched, the words a strange and haunting wail. The singers sat with their bodies hunched a little forward and their eyes shut tight. They strained to get the sounds right, to keep the rhythm, to take and keep themselves elsewhere. This was no longer skid row – or was it actually the very heart of skid row, where those who lived as marginals could be themselves at the centre of the white man's city?

The songs were separated by quiet pauses, a hand passing the bottle, a shifting of bodies, but no one spoke.

After one of the songs, a young woman broke the silence and said to me: 'Now you hear our minds, in our song. How come the white man says we have no mind? When they hear a Cree song, I guess they think it's a coyote howling.'

Everyone laughed.

8

20th-century cameras have allowed us to look into the eyes of the wildest of animals. There is no corner of nature, however remote or small or dangerous, that does not appear in intimate proximity on television screens. At the same time, researchers into animal behaviour and its genetic sources are developing ever more sophisticated techniques for seeing the mechanisms and achievements of the natural world. There is a new kind of relationship, based on technical sophistication and the knowledge of experts, between humans and the rest of nature. Photographers and scientists are the wizards, if not the shamans, of our age, making revelatory journeys into places where, in the course of ordinary life, the rest of us cannot go. We rely on them to show us the world that is not human.

This ever-increasing closeness to the natural world influences our sense of the dividing line between human and animal. We discover an unexpected complexity of animal systems and learn about the intricate links between one animal and another. We find that there are divisions of labour, with one part of an animal community raising newborns, others getting food, and others defending the group. We are shown the sophisticated behaviour required to capture or evade capture, elaborate forms of courtship, and myriad forms of communication. We discover that leaf-cutter ants make gardens and harvest crops; that gannets can recognize their own nests among a hundred thousand others; that humpback whales coordinate their fishing; that in some species, monkeys can warn one another about several different kinds of impending danger; that male fruit flies sing elaborate love songs to court females. These are occupations and purposes that we understand. They depend upon qualities, characteristics and motivations that humans also possess. Detailed portraits of the natural world again and again reveal similarities between humans and other beings. The evidence of DNA, with its apparent overlap of gene sequences between mushrooms and people, is the newest way in which the lines between us and the rest of nature can seem to be uncertain.

This apparent blurring of the divide could also be seen as an echo of shamanism. Perhaps the boundaries around the human are less definite, more porous, than most scientists and many farmers have tended to suppose. Animal rights advocates often make this kind of argument; they point out that the use of animals for experiments, or even as food, depends on human beings keeping animals in a separate and inferior moral category. The promise of Genesis is integral to the domestication of animals and to their use as a resource. The exiles from Eden go forth and have dominion.[10]

In fact, real shamans – as opposed to those who provide wildlife programmes for television or make new-age forms of argument – say that humans and animals exist in separate domains. In the shamanic myths of very ancient times, humans and animals lived in the same circumstances, able to speak and procreate with one another. But these myths also tell of how ancient times yielded to an era in which the divide between humans and other creatures became much clearer. Indeed, the need for shamans, or for spirit possession, derives from the periodic need to cross this divide. Hunter-gatherers and their shamans insist that life depends on maintaining the right kind of relationship with the natural world, and the negotiations necessary to sustain this relationship are difficult. The power of the shaman centres on this difficulty. By overcoming it, the journey can be made from human to animal and back again. This is the power that comes from transformation.

When we look into the eyes of animals, be they pets or creatures that we hunt, cows and horses on the farm, dogs in our homes, or the subjects of wildlife documentaries, we seem to see thought. Animals watch, wait, appear to ponder. They look as if they are assessing one another's movements in order to make sure that their own are safe or effective. They give many signs that they are thinking.

In 1999, British television broadcast a wildlife programme made with a new level of film technology: it had become possible to film in almost complete darkness. The footage included sequences of lions stalking and killing their prey. They moved with great stealth, peering, watching, calculating, manoeuvring. Several individuals collaborated to approach and surround their prey; two remained still, one continued to move closer. Then, with great skill and precision, they made their attack. Were they thinking? Surely they must have been. To calculate in this way, to make decisions about how best to carry out the kill, must require some form of thought. Or is this so? It is very hard to imagine thought without language. And these lions do not speak; they have no more than the most minimal form of vocal communication. Their brains work without words.

This wordlessness is integral to how we see animals. It arouses in us a form of gentle sympathy, an anthropomorphic kind of pity. It also means that, for all their ferocious killing of weaker species, we see animals as innocent. Those lions do not lie, because to tell a lie requires speech; they cannot be condemned for the cruelty of their ways, because morality arises only with articulate thought, in words. The lions show a kind of purity of judgement, rather like pure emotion. There can be no process of the kind that depends on thinking as a silent form of speech. Lions do not talk to themselves. When we look at them we see, rather, the strange dumbness of the animal as it thinks without thoughts. We see feelings that we recognize, of course: fear, excitement, even pride. These feelings also arouse our sympathies. But animals are untainted by the ambiguities and distractions and complexities of what humans know to be the heartland or even defining features of thought.

9

'What, then, is the difference between brute and man? What is it that man can do, and of which we find no signs, no rudiments, in the whole brute world? I answer without hesitation: the one great barrier between the brute and man is language.' These are the words of Max Müller, among the first theorists of language, writing in 1875. Müller's view has been shared by many others, including late 20th-century scientists who have sought to identify the part of the brain where the potential for language resides. Language theorist Derek Bickerton observes that language is probably 'the antecedent of most or even all of the other characteristics that differentiate us even from our closest relatives among the apes'. The miracle of this ability to understand, use and make language is the miracle of being human. 'Simply by making noises with our mouths, we can reliably cause precise new combinations of ideas to arise in each other's minds.'[11]

There has always been a popular view, endorsed to some extent by Darwin's ideas about language, that places the calls of birds and the cries of animals on a single spectrum of communication. This is to say that humans do the same as animals, except that they do it more and better. Yet the attempts of primatologists who spend years teaching a chimpanzee to recognize and in some way make use of four or five words, or the intensive efforts of marine biologists to decipher the communication systems of dolphins, are projects that seem to confound any claim that even the most intelligent of other mammals have anything like language. They communicate, but they do not have language. There is no equivalent of grammar or syntax; no parallel, therefore, to the way human children learn to speak. Animals do not do what humans call thinking. They may exist in a Zen-like state, where the brain works without self-consciousness (consciousness is also inseparable from words), but they are not thinking. This is why animals are outside moral judgements and why, also, they inspire such a sense of puzzlement. To look into their eyes is to see a creature with a brain. We see facial expressions and even gestures that are very like our own. Yet something is missing.

We humans may be able to get a sense of animal 'thinking' from our remarkable capacity to make quite complex decisions without thought. The driver of a car who suddenly has to deal with an emergency is capable of making a quick set of decisions – changing gears and speed and direction – without any apparent thinking. Similarly, drivers of cars often have the experience of picking the route home without being aware of doing so. Actions of this and many other kinds are said to be unconscious, in that the thinking takes place somewhere other than where we are using – or are aware of using – language. The terms 'mindless' and 'thoughtless' indicate the significance of action that fails to proceed from the necessary mental processes: such behaviour is wrong, in either a moral or a practical sense, precisely because we did not think – that is, we acted without the benefit of words.

In mythology and literature, creatures that are almost human are often monsters. Their animal characteristics are exaggerated in a symbolic manner: they represent the frightening power of the animal in ourselves. These creatures are somehow primitive or savage; they take human shape, yet are outside human culture. And their condition draws its most poignant qualities from their lack of articulate language. Prospero's Caliban, Beauty's Beast, King Kong, Marian Engel's Bear. The stories in which such characters have greatest effect are those in which they are discovered to be innocent despite their apparent beastliness. They are without the guile of language.

When human beings began to use language, their brain structure made an evolutionary leap of huge importance. The physiological difference between those who spoke and those who did not may have been very small, a tiny fraction of the total brain. But once it was there, a divide opened up between human beings and all other animals, a divide that had immense and ever-expanding consequences. Language allowed human evolution to take a very different and much more elaborate path.

In the absence of language, inheritance is limited to the gene pool. Parents pass on to their offspring a bundle of genes and very little else. But with language, they can pass on vast bodies of knowledge, moral codes, forms of social arrangement. And with language, it is possible to think. With thought, it is possible for each generation to transform knowledge and ideas, which are then passed on to the generation that follows. Once it had language, the human species spread throughout the world, from environment to environment, each group with its own ways of occupying territory, knowing about their land and ordering their lives in a particular region. In this way humans came to live in cultures – that is, in many kinds of articulate and organized societies.[12]

The human mind is this combination of language, thought and culture. The capacity to be human is inseparable from the capacity to think, be articulate and change life through words. The best-trained chimpanzee and the least-educated human being are far, far apart in linguistic skills. The one has nothing more than a tiny number of words it can use in restricted conditions. The other has grammar, syntax and hundreds of words that he or she can use in any circumstances. The human mind, at its least, is rich with potential that makes human evolution unlike anything else in history. All the mind's capacities are shared by all humans, irrespective of any other consideration. Each culture may give rise to its own kind of mind. But mind is what gives rise to culture itself.

10

No one knows when human beings first used language. *Homo erectus*, the human ancestor who lived about 2 million years ago, used tools and has been declared by some archaeologists to have had many qualities that are more human than animal. But the kind of tools *erectus* used seem to have remained unchanged for about a million years, and the structure of its upper body suggests that it did not have the breathing system necessary for elaborate speech. As one scholar has put it: 'If these ancient people were talking to each other, they were saying the same thing over and over again.'[13] The evidence that does suggest language, where the tool kit is complex and changing and where the physiology of the upper body is consistent with the use of speech, comes from about 800,000 years ago.

The dating of the acquisition of language, however, is less important in this context than the nature of the process. Did language appear through a long and gradual evolution, with lower levels of linguistic achievement giving way to higher levels? Or was the ability to use language a more sudden, cataclysmic event, or set of events, which meant that humanoids became humans in a revolutionary change to the mind? The importance of this issue is very great. A slow process means that different peoples could have been at different levels of linguistic ability, or that languages with different forms of linguistic sophistication could have emerged and disappeared. A revolution means that a single evolutionary development created the mind of the original *Homo sapiens*, the ancestor of all modern human beings.

Various kinds of evidence suggest an answer to this question. There is, first of all, what seems to have been a sudden explosion of human culture – the great spread of hunter-gatherer systems around the world, each with its own sophisticated and specialized technology. Then there is the evidence of language itself. What has been called 'the language instinct' turns out to be fundamental to the activity of all human minds, even those denied the normal means to develop language. Every child acquires or uses grammar, irrespective of the circumstances. And given even minimal language-learning opportunities, children begin to employ grammatical techniques with astonishing speed, soon applying linguistic rules and making their own sentences – ones that they could never have heard before. These findings suggest that the capacity for language developed in a short period of time and by means of a specific evolutionary leap – the ability to acquire and employ grammar.

Some experts have argued that the ability to learn a language is 'hard-wired' into the human brain.[14] By this they posit the existence of a faculty that serves as the language-learning element in the human mind. In other words, this is the capacity to be a human that all humans inherit; and it is this capacity each society then relies upon to build its particular array of knowledge, skills and norms. The immense evolutionary advantage that came with this hard-wired faculty lay in the way humans could think, know and distribute resources in collaboration with one another, in ever-changing ways. The social dimension of language is thus intrinsic to both its form and its opportunities.

These pieces in the jigsaw of human prehistory can be assembled to show a picture of human beings living in groups that use language, and therefore thought, to deal with all their concerns. The universal qualities of mind mean that humans are able to learn one another's languages. One person knows more or less than another. One person is more eloquent than the next. But all of us share the faculty that makes eloquence possible.

Languages rely, of course, on the sounds that people make. Linguists have identified some 140 separate pieces of sound – the total for all the world's ways of speaking. English uses about 40 of them; Norwegian, the most elaborate vocal system of all Indo-European languages, uses about 60; Inuktitut uses about 50; there are Bushman languages in southern Africa that use about 120. As one of the world's most eminent linguists has said, the Bushman is 'the acrobat of the mouth'.[15] This wide range of sounds does not suggest that the sophistication of a particular culture has any links with the outward complexity of its language or languages. Nor are there differences in grammar that indicate any one language is more or less evolved than another. The popular idea that some languages are 'primitive' is false. Each language has its own sophistication, but all share a basic level of intellectual achievement.

The Khoisan languages, which may have the most direct links to the birthplace of language itself, have been despised by Europeans as 'the chattering of monkeys'. In reality, the Khoisan use about 85 per cent of all language sounds. This is not to argue that their languages are *more* complex or can therefore achieve greater intellectual heights than those of other peoples. The point is that they are not *less* complex. There is no relative simplicity of language. The underlying faculty for language, the hard-wired component of the human brain, is universal: an ultimate equality of opportunity.

11

The brain struggles when it comes to thinking about thinking. Being able to speak, however, may have much in common with other kinds of human natural potential – to have arms, for example, or a particular arrangement of nerves. Noam Chomsky, the most influential modern theorist of language, has described an important implication of the similarity between the capacity for speech and other capacities:

> No one would take seriously the proposal that the human organism learns through experience to have arms rather than wings, or that the basic structure of particular organs results from accidental experience. Rather it is taken for granted that the physical structure of the organism is genetically determined.[16]

Chomsky makes this self-evident observation to support his proposal that the underlying feature of language – the thing in every human brain that makes language possible – is also a physical structure that is genetically determined. Chomsky situates the source of language, the piece or pieces of the brain that make language possible, alongside other faculties that are inherited rather than learned. In the same context, he goes on to ask: 'Why, then, should we not study the acquisition of a cognitive structure such as language more or less as we study some complex bodily organ?'

According to Chomsky and other researchers, the speed at which a child's vocabulary grows, and a child's ability to use grammatical rules, are not influenced by teaching. Studies have found that attempts to correct children's grammatical errors by repeating the correct form back to them are unsuccessful. Researchers looking at cases where parents corrected their children's English found that this correcting 'had no effect – if anything, it had an adverse effect – on the child's subsequent development'. This research, and the discovery that children do not respond to being taught correct grammar, is discussed in Steven

Pinker's remarkable book *Words and Rules*, which builds on many of Chomsky's original insights.[17]

Pinker focuses attention on irregular verbs as indicators of how the brain acquires, builds and uses grammar. In this context, he looks at studies of identical twins, noting that 'vocabulary growth, the first word combinations, and the rate of making past-tense errors are all in tighter lockstep in identical twins than in fraternal twins'. Pinker's striking conclusion to a chapter centred on the relation between nature and nurture in language learning is clear enough: 'Every bit of content is learned, but the system doing the learning works by a logic innately specified.' This account of language learning establishes that every child inherits a fundamental set of characteristics prior to and independent of culture. These create the possibility of language and also set the limits to what can be taught.

Findings from the modern heartland of linguistic theory are consistent with hunter-gatherer ideas of child raising and education, in which children are expected to develop in their own ways, at their own pace. Nature is relied upon to do its part in the business; the mind is expected to grow very much on its own. Pedagogy is viewed as of limited benefit at best, and as counterproductive at worst. Children learn when and what they are ready to learn.

In Inuktitut, there is a linguistic indication of this faith in the extent to which human potential is hard-wired. When a person experiences extreme grief, he might say '*Isumaga asiujuq*'. 'My *isuma* is lost; I am out of my mind.' When Anaviapik's son Inukuluk was talking about his experience of adult education and his struggle to 'be a white man', he began what he said with '*Isumanguar*', 'appearing or pretending to think', which I translated as 'I sort of thought'. And in many conversations I heard '*Isumatuinnarpunga*', 'I just thought', a caveat that conveys the sense of the English words 'It's only my opinion'. The root *isuma* has many uses; they show it to be something that also has an independent existence. In Inuktitut, thought is tightly linked to the capacity for thought.

When a child misbehaves or misunderstands, adults are likely to say '*Isumaqijuq*', meaning that she lacks *isuma*, is without the necessary thought. It is striking that in this use of *isuma*, the child is no more blamed for this lack of thought, for having an undeveloped *isuma*, than she could be criticized for having short legs or a large nose. Everyone is aware of a child's development, in body as well as mind. Comments are made noting progress. These comments are not judgemental, though they will, of course, have their effect. Social pressure comes from what a child hears said about her. Adults do influence the way a child learns, shaping aspects of character and affecting the rate at which many kinds of learning take place. But the Inuit trust that individual development comes from what goes on in the child, not from any systematic pedagogy. *Isuma* grows at its own pace. A child has the potential, and she will grow in her own good time. Once the capacity has developed, and there is a mind and language that expresses mind, then some children will learn better than others. External factors come into play, just as they do with the strength of arms and legs. But for hunter-gatherers, the individual mind is the thing that must choose to learn, develop, make decisions. Pressures from others on that mind, according to the deep beliefs and social conventions of hunting peoples, are more destructive than instructive. The mind has the capacity to learn, and, left to develop on its own, it will do so.

The place of thinking in Inuit ideas of psychological development, and the related ways in which the word *isuma* is used, offer many clues about Inuit society. Parents identify children with respected elders, trust children to know what they need, do not seek to manipulate who children are or what children say they want. This way of treating children tends to secure confidence and mental health. And Inuit child raising is inseparable from many aspects of interpersonal behaviour. Adults respect one another as separate but equal. This is the basis for cooperation – by respecting individual skills, judgements and knowledge, the strengths of the economy and the social order are shared. *Isuma* is the notion that underlies and unites many of these features of Inuit life, for it affirms that in crucial ways the development of *isuma* is independent of social manipulation and control. Embedded in this use of the word for mind is a view of mind itself.

The work of Chomsky and Pinker and the Inuit use of *isuma* reveal the same truth: there is some logical and physiological antecedent to the cultural specifics of learning. In the hunter-gatherer reliance on individual egalitarianism lies the freedom for everyone to be themselves, and a confidence that the integrity of society – the respect that hunter-gatherers show to one another as well as to the natural world around them – will achieve the best results for both individuals and the group. The egalitarian individualism of hunter-gatherers is of a piece with a compelling theory of mind.

12

The linguistic theories of Noam Chomsky have been closely associated with the school of thought, or the theory of thought itself, known as structuralism. Structuralist theory originates with ideas about grammar and its relation to the structure of the mind, and it relies on the view that grammar has at its heart a logical principle akin to the law of excluded middle, the principle that nothing can be both X and not X at the same time. The merits of this approach to grammar may well be inseparable from the insights of Chomsky and others into universal grammar. But anthropology made structuralism its own with a series of assertions about a seemingly fundamental dichotomy between culture and nature. Beginning with these ideas as a way of looking at ritual and myth – seeing rituals and myths as expressing or mediating the need for humans to establish their cultures in defiance of nature – structuralist anthropology then proceeded to explore many other kinds of dichotomies, some of which resonated with the culture : nature paradigm. Man : woman. Dark : light. Raw : cooked. Upstream : downstream. Sky : earth. Sun : moon. Human : animal.

The anthropologist who made the most elaborate play with pairs of opposites, and who originated the claim to see in them a clue to the nature of the human mind itself, was Claude Lévi-Strauss. Lévi-Strauss's followers in the English-speaking world were led by Edmund Leach, who for many years was professor of anthropology at the University of Cambridge. Their views became an orthodoxy. No ritual or myth, no piece of social life or sacred text was safe from a grid of interpretive dichotomies. This 'structure' was set out as if it were an explanatory reduction of social and intellectual life, a scheme that laid bare some primary meaning.

When I first read Lévi-Strauss in 1967, I was impressed by the originality and apparent insight of his way of writing about both tribal and European cultures.[18] In *Tristes Tropiques* and *The Savage Mind*, and then in his ever-burgeoning *Structural Anthropology*, Lévi-Strauss carried a generation of intellectuals on a wave of ideas that began with Cartesian philosophy and proceeded to overtake all branches of sociology and philosophy. This was work that addressed central questions about reason and mind, while taking the reader to tribe after tribe. Lévi-Strauss's description of the Nambikwara, hunter-gatherers of the Amazon, was both compelling and poignant. Here were people whose material simplicity was matched by extraordinary cultural beauty, and yet they were disappearing from the world. His account of the myth of Asdiwal, collated from Nisga'a stories set in the Nass Valley, with its hero figure moving up and down the river and between the earth and the sky, was analysed into binary pairs as if it were underlain by a kind of mathematics of human consciousness.[19] To read this work was to experience a sense of intellectual wonder, to feel that one was being led on a journey of remarkable discovery. Yet the journey was oddly frustrating, as if it passed through fabulous landscapes but never reached a destination. The ideas floated high above reality, circling; and many of us circled up there with them, not sure where we were or where we were going, in awe of the height, feeling uneasy, but not quite daring to land. Over the years, the magic of the journey faded; a sense of dissatisfaction remained.

In retrospect, the trouble with the intellectual claims of structuralism is not hard to discern. To say that a tribal myth contains opposing elements, and that its structure is demonstrated by laying these out in a formal manner, revealing at the same time dichotomies that are otherwise obscure, is to explain nothing. The analysis may well claim that a reduction of these pairs shows them all to be expressions of the fundamental opposition of culture to nature. But what is the explanation being made of the myth? The myth expresses the core issue of all societies: to establish how human life seeks to separate itself from natural life. Or the myth expresses the deep nature of human mind, the structure of mind itself, where dichotomies lie at the heart of us all. But these are not explanations of anything. To say that a myth expresses the core of society and the nature of mind is to say very little. Myths and ritual are the products of language and society; it would be strange indeed if they did not give expression to them.

Structuralism in anthropology is an elaborate and at times fascinating game. It looks scientific, for it has a direct link with scientific linguistic theory and follows scientific methods of exposition, deducing an underlying reality from social, verbal and textual surfaces. But there is no explanatory achievement that goes beyond an a priori assertion about the structure of mind and a somewhat tautological process of deduction: the theory knows what it is going to find, then relies on a thorough but predictable exposition to find it. It is very striking that when Edmund Leach wrote about the Bible, and gave himself the task of explaining the nature of much of the text, he showed how a particular complexity of the stories is in the interest of a priestly class. Here is an explanation, but it is to do with function, not structure.

A further objection to structuralism in anthropology is more down-to-earth. The use of binary pairs to create an analytical grid is at odds with the way in which indigenous cultures, starting with hunter-gatherers, achieve so much by avoiding dichotomies. Hunter-gatherers also reject any complete reliance on deductive reasoning. So the structuralist analysis that commits from its outset to display the inner workings of dichotomies is in a perplexing, and somewhat imperial, relationship to its subject matter. The anthropologist's ways of thinking here occupy the intellectual territory, obscuring and ousting the people's own modes of thought and discourse. An irony of Lévi-Strauss's achievement is that it yields much more insight into his own culture, so centred on binary logic and attempts to create rational order, than into those of the tribes he examined.

Postmodern work in literature and social science has emerged in part from frustration with this structuralist reliance on dichotomies and its attendant pseudo-scientific qualities.[20] These new approaches to history, culture and knowledge centre on meaning rather than on mind. And they pay close attention to the ways in which meanings themselves are constructed by the would-be analysers. Thus postmodernists deconstruct the accounts, be they myths or theories of myths, allowing presuppositions, intentions and colonial purposes to disclose themselves in whatever array of complexity or contradiction may emerge. It is easy to imagine the intertwining puzzle that this exercise in scrutiny can yield.

The postmodern task is the analysis of analyses – an approach that can indeed yield insightful theories about theory. Its problems, like those of structuralism, stem from a failure to describe a world whose reality would be recognized by those who spend their days living in it. The deconstruction of hunter-gatherers has contributed to the view that they do not exist at all; they become, instead, a myth of colonial theory, a part of someone else's ideology, or, at best, an edge of some other way of life. To those who live, or whose ancestors have lived, by hunting and gathering, this deconstruction must come as a surprise.

13

Let me return for a moment to dichotomies, this time to the pair of terms that I have relied upon not only for the writing of this book but in much of my thinking about the world. In my notes and letters, places where writing is not laundered for fear of critics, I have long used the pair of abbreviations h-g : p-g. These stand for hunter-gatherers and potato growers. This pairing began as a small and rather obscure joke about the romantic appeal of hunter-gatherers in their vast territories opposed to the confined, harsh lives of peasants in their fields of potatoes. The joke – if it can claim to be more than a piece of grim and private humour – needs some explanation.

I began anthropological work in the west of Ireland. I spent long periods of time living and working with men and women whose lives centred on small gardens and a few fields. This was an experience of peasant life. And all the notions and tensions of what it means to be a farmer in Ireland turned my attention to potatoes. The history of the families I knew, and the stories of their farms, had been shaped by the potato. Peoples' attachment to their fields, their occupation of the hillsides and bogs and islets of the west coast, were made possible by potatoes. They could live on ever smaller areas of ground and still feed large numbers of children thanks to the potato's remarkable productivity and nutritional value. The shattering of this system, the breaking of the cycle whereby each family would divide its holdings to allow the sons to inherit land, and in which sons and daughters would marry young and begin their own households, was the result of the potato famine of 1846–1851.

The Ireland I knew had its roots in the changes after the famine.[21] Not that the potato was gone; rather, it could no longer be the basis for an ever-increasing farming population. Modern Ireland was born of potato blight and a population that was declining fast. The language of modern Irish writing (some of James Joyce, Samuel Beckett, Sean O'Casey, Patrick Kavanagh, even Seamus Heaney) reflects all this, though I know there is a harking back to the 'real' Irishness of pre-famine days in Yeats and Synge. These Irish 'traditions' were of short duration, but the potato was always there. It shaped the harshness of the work and became the condition of both attachment to the farm and the inevitable emigration of so many to other places. The history of the potato in Ireland provided a chance to see, in stark and clear form, the reasons for and consequences of the exile from Eden. Here were peoples who were indeed enduring the curses of the God of biblical creation. They lived by the sweat of their brows, gave birth to many children, then had to go forth and multiply elsewhere.

After living in and writing about Ireland, I travelled to the lands, lives and stories of hunter-gatherers. I have already described the intense feelings this gave me of making a journey to a very different kind of human condition. The immense landscapes were matched by human beings who seemed to be free and at home. I had made a move from the realm of troubled exiles to the other side of Eden. Through this move I was to discover a contrast that was both personal and anthropological: I felt liberated from the anxious inner landscapes of middle-class Europe, and I was able to experience the warmth and ease of people who have the deepest possible sense of being in the best of all possible places. So the h-g's came to oppose the p-g's, the hunter-gatherers the potato-growers.

One absurdity of this construct is obvious enough. Potatoes came from the Americas, and were domesticated there, I would imagine, by peoples more in the hunter-gatherer mould than in any other. There must be a better agricultural abbreviation, one that refers to some resource other than potatoes. The obvious candidate is g-g, grain-growers. At least this makes a childlike pun on the existence of the horse (gee-gee), though this is a creature that can leap across the divide – as, of course, it did when Indians in the Plains and the North-west got hold of horses in the 1600s. In fact, the h-g : p-g abbreviation, along with its alternatives, should be put aside so that other weaknesses of this dichotomy may be confessed.

Hunter-gatherers rely on wild animals and plants. But there are many indigenous societies that depend on domesticated animals and crops – tribal peoples who are not hunter-gatherers. Relations between these two forms of indigenous economy are often marked by mutual suspicion and animosity, with tribal agriculturalists tending to despise their hunter-gatherer neighbours. James Woodburn, the British academic who has made some of the most important contributions to hunter-gather anthropology, summarized the kind of discrimination that hunter-gatherers have suffered from their pastoralist neighbours in southern Africa, noting that they tend to be described as 'dirty, disgusting, gluttonous, ignorant, stupid, primitive, backward, incestuous, lacking a proper culture and language and even as animal-like, not fully human.'[22] He goes on to explain how these attitudes are often accompanied by deep fears about the apparent exotic powers of hunter-gatherers. The important point here, however, is that the divide between agriculturalists/pastoralists on the one hand and hunter-gatherers on the other appears between indigenous societies as well as between hunter-gatherers and European settlers. Both the sociology and the colonial histories of Australia, North America and southern Africa justify, and can be illuminated by, some version of the h-g : p-g distinction.

In the Americas, some indigenous agriculturalists developed the dense populations, severe inequalities and military aggression that I have linked to settler farming. Similarly, to reflect on the ancient history of Europe, where farmers occupied hunters' lands millennia ago, is to contemplate the possibility of many mixed economic systems. Farming peoples moving into new lands would have relied on herds and hunting while they established fields and waited for crops to grow. Some hunter-gatherer societies, having exhausted their supplies of wild game, either adopted a form of agriculture or pastoralism or entered into complex dependence on neighbours who were farmers or herders. And hunters in many regions may well have tried to farm or make use of domestic animals as adjuncts to their hunting systems. The evidence of language, as I have said, argues that the farmers overwhelmed the hunters. But this does not mean that farmers were not also hunters or that the hunters, before being overwhelmed, did not attempt some farming.

Anthropological accuracy requires, therefore, a great deal of caution about the hunter : farmer dichotomy. In reality, there is a possible spectrum of economic systems – with hunters at one end, farmers at the other, and many kinds of mixture in between – rather than two exclusive categories, some pairs of opposites that between them include all possible human societies. In this respect, the hunter-gatherer : farmer divide is itself a form of myth.

Nonetheless, I believe that within this distinction lies a set of intellectual and imaginative opportunities. Thinking about the place of hunting peoples in the human story offers an insight into the history of the world. It provides a parallel insight into the nature of the human mind. The destiny of the hunter-gatherer is both an external and an internal process, an issue for societies and for individuals.

14

The hunter-gatherer mind is humanity's most sophisticated combination of detailed knowledge and intuition. It is where direct experience and metaphor unite in a joint concern to know and use the truth. The agricultural mind is a result of specialized, intense development of specific systems of intellectual order, with many kinds of analytical category and exacting uses of deductive reasoning. The hunter-gatherer seeks a relationship with all parts of the world that will be in both personal and material balance. The spirits are the evidence and the metaphors for this relationship. If they are treated well, and are known in the right way, and are therefore at peace with human beings, then people will find the things they need. The farmer has the task of controlling and shaping the world, making it yield the produce upon which agricultural life depends. If this is done well, then crops will grow. Discovery by discovery, change by change, field by field, control is increased and produce is more secure. The dichotomies of good and evil, right and wrong express this farming project: control comes with separating manipulable resources from the rest of the environment and working with determination and consistency against all that might undermine this endeavour.

The differences between hunter-gatherers living before agriculture developed or beyond the later farming frontier, and small indigenous societies based on a mix of farming, herding, hunting and gathering, may not best be understood as issues of mind. As noted, ideas about spirituality and the boundaries between the physical and the metaphysical are shared by many indigenous societies, both hunter-gatherers and small-scale farmers. However, all agriculture depends on controlling and remaking the natural world, and farmers have the task of both defending their fields and finding new ones. These are social and economic reasons for relatively high levels of organization and aggression. It is no coincidence that in so many parts of the world, including regions where different indigenous systems live alongside one another, agriculturalists despise hunter-gatherers for being 'primitive' and hunter-gatherers complain that farmers are belligerent. In the colonial era of the past 500 years, 'developed' agricultural societies have launched themselves with particular ferocity against all other peoples, and have, in particular, sought new land in vast territories occupied by hunter-gatherers. However complex the overlap between different kinds of indigenous societies, the dichotomy of hunter-gatherer : farmer says a great deal about how the world and the mind have been shaped.

Two ways of being in the world yield two kinds of human condition, each with its own set of circumstances. History reveals that exponents of the one have made war on the other, and the world has changed accordingly. Yet these different ways of thought are, as potential, within everyone. Human beings can reach into themselves and find two versions of life, two ways of speaking and knowing. Internally, many people are torn between these two ways. Individuals are born into one or the other society, and therefore learn its particular skills and disposition; but nobody is born to be either. The potential for language, and therefore for thought itself, is a shared human characteristic. The specifics of the language that are learned – not language itself – are what embody the intellectual and personal characteristics of one or another kind of mind and society.

What makes us who we are? Things we inherit, be they aspects of body or the hard-wiring of the mind. But language means that much of who we are does not lie *within* us as individuals so much as *between* us. The child is shaped by the society she lives in as a result of how others speak and behave towards her. All of us learn and live in relationships with one another: much of our reality lies in how these relationships take shape, function and maybe fail. Much of who people are comes from events and processes that are more than just internal and personal. And this is where we can see a particular importance of hunter-gatherer societies: they have established and relied upon respect for children, other adults and the resources on which people depend. If these relationships are not respectful, then everything will go wrong. The sickness of particular individuals, the failure of the hunt, the weather itself – these are all expressed in terms of relationship. The egalitarian individualism of hunter-gatherer societies, arguably their greatest achievement and their most compelling lesson for other peoples, relies on many kinds of respect.

The hunter-gatherer achievement, however, is not a matter of mutually exclusive qualities. Every healthy human being has the potential for all human qualities; nobody develops one kind of strength to the complete exclusion of its opposite. To this extent we are all hunters *and* farmers. The differences between one kind of society and the other are therefore to do with balance. And the imbalance has arisen because farmers have achieved such complete domination over hunter-gatherers.

Many hunter-gatherer societies have made accommodations to farmers and herders. In many parts of southern Africa and South America, hunter-gatherers have created gardens and become shepherds or farmworkers or suppliers of pots and spears. In North America, many became cowboys, and some worked as domestic servants. Modern hunter-gatherers have taken advantage of farmers to supplement their own resources, or they have looked to the new wealth of farmers to help them deal with the loss of land and the destruction of wild animals that the farmers' arrival has caused.

But in many places, in many ways, hunter-gatherers are not at ease with farming and herding ways of life. Again and again, the farmers, while using their hunter-gatherer neighbours as casual and cheap labour, complain about their 'unreliability'.

The hunters want to go hunting; gatherers like to gather. Hunter-gatherers tend not to plan and manage surplus. They need food or money now, not in several weeks' time. In the modern world, the hunter-gatherer often appears to be restless as well as poor.

The genius of hunter-gatherers is not rooted in their readiness to learn from or to work for others, however widespread these attributes may be. The compelling expression of hunter-gatherer culture lies in the balance of need with resources; the reliance on a blend of the dreamer's intuition with the naturalist's love of detailed knowledge; and the commitment to respectful relationships between people.

The hunter-gatherer within the modern, urban world is not extinct. Remaining hunter-gatherer societies continue to exhibit the qualities they have always possessed. And there are also hunter-gatherer points of view, beliefs and habits of mind within the farmers' world, inside the nations and towns that the exiles from Eden have established and from which they continue to press outwards with a nomadic imperative. Some anthropologists have pointed to the presence of people who forage at the urban community's social and economic margins – men and women, even some families, who make do on a day-to-day basis, relying on resources that are found here and there rather than earned from the routines of daily labour. This portrayal of the hunter-gatherer in the modern city accords with widespread images of hunter-gatherer destitution and landlessness. It speaks to loss rather than to achievement.

But there are more optimistic views of the hunter-gatherer in the urban setting. Indeed, there are eruptions of the hunter-gatherer mind in the farmers' world, as evidenced in the many voices raised in opposition to the unquestioned dominance of the agricultural way: protests against repressive order, bureaucratic planning, chronic inequality, patriarchal conceit, poisonous pedagogy and the denial of all that is essential to art. These are arenas in which a rival mind seeks expression and longs for its particular forms of freedom. Throughout the Western world, there are men and women who consciously choose low levels of material comfort and small numbers of children to avoid the need for large incomes, thereby pursuing lives in which they may survive without regular jobs and devote themselves instead to creative work and family life. This way of being encompasses a concern about the destruction of the natural world by the ever-growing pressures to reshape it in the interests of surplus and profit. And dissident voices within mainstream culture have long criticized the use of repression and violence both in maintaining social order and in raising children. In all these we can hear echoes of hunter-gatherer ideas and practices.

Men and women galloping on horses across the countryside in pursuit of foxes; men with shotguns who fire at pheasants, grouse or partridges driven towards them by a line of beaters; those whose wealth allows them to trawl the seas for game fish in their powerful boats – these people may claim to represent the hunter-gatherer within us all. Yet their habits and minds are fixed firm to the farming condition. Their hunting, shooting and fishing is evidence of the very characteristics that agricultural development has exaggerated, with the help of capitalist and industrial developments, to an extreme. They are suppressors rather than exemplifiers of the hunter-gatherer. They live by the systems of privilege and organization that are hallmarks of the agricultural mind.

No: the hunter-gatherers in the heartland of the exiles, living in the nation-states of farmers and in the cities farmers have built, are opponents of the dominant order. They oppose hierarchy and challenge the need to control both other people and the land itself. Consciously or not, they are radicals in their own lives. At the least, they experience the tension in themselves that comes from a longing not to plan and not to acquiesce in plans; at most, they use a mixture of knowledge and dreams to express their vision. It is artists, speculative scientists and those whose journeys in life depend on not quite knowing the destination who are close to hunter-gatherers, who rely upon a hunter-gatherer mind.

The visionaries in society are always there, and they are perhaps a part of us all. The agriculturalist mind and its economic order never quite obscure evidence of the hunters. Many people feel the strain of a way of life and a mindset that disallow all forms of improvisation and intuition. The controlling features of a life that has no place for the hunter-gatherer mind create a longing for spirituality and underpin many forms of protest, from Quaker ideals of equality to the call for deschooling society, from New-Age mysticism to concern about rainforests.

There is a common experience of something being wrong that may receive real illumination from a much more direct acknowledgement of rival forms of mind. Rival forms of mind are, of course, reducible to rival forms of society – and, in the end, to the displacement of one kind of economy by another.

Hunter-gatherers may well represent a need in all peoples to experience a profound form of freedom. But they are also within the social universe in a literal way: there are hunter-gatherer societies, along with other indigenous peoples, whose demands for cultural survival and actual territories are no less vociferous than they ever were. In every part of the colonial world, the issue of aboriginal rights is alive as an issue whose urgency and poignancy are augmented by the prospect of a final destruction.

In Australia, Aborigines contest government and industrial invasions of their lands. There have been struggles in the courts, in political campaigns and on the land itself. Settlers still want to eliminate hunter-gatherer claims to the Australian outback. Aborigine organizations protest, and in some crucial places win, their right to their own way of life, their own heritage, their own place on the earth. In 1992, the Australian High Court established a common law principle of native title to native lands.

In South Africa, the -Khomani San, the remaining Bushmen of the southern Kalahari, have managed to survive their complete displacement and dispossession, after 50 years of subsistence at the most destitute margins of South African farms and townships. With the fall of the apartheid system, these few survivors began a campaign for the return of their lands and for the right to live in whatever combination of social and economic systems they choose for themselves. In March 1999, the South African government accepted their claim and agreed to return some

50,000 hectares of original -Khomani San territory. In Amazonia, Colombian hunter-gatherers have been mapping their territory as part of new negotiations with the government, which has at last moved towards recognition of tribal rights to tribal lands.

In Canada, the land-claims era that began in 1971 has led to a number of settlements that recognize hunter-gatherer heritage and lands. The Cree of the James Bay area in northern Quebec have managed to secure the basis for a hunter-gatherer economy in a large and complex settlement of their dispute over the flooding of much of their lands to create hydroelectric dams. The Inuvialuit of the western Arctic have negotiated a settlement of their claim to aboriginal title in a large area in the Mackenzie Delta and adjacent islands. The Gitxsan and Witsuwit'en have won much greater basis for their rights in the Supreme Court of Canada. The Nisga'a have reached an agreement with Canada that gives them a core of territory and extensive rights of self-government. And the Inuit of the North-west Territories have secured from the Canadian government a territory and jurisdiction that is based on the spread of their hunting territories in the eastern Arctic. This is the new territory of Nunavut – the most ambitious attempt in the history of the encounter between colonists and hunter-gatherers to secure coexistence at the frontier.

These victories are all the result of modern political processes. They represent a small proportion of the struggles and claims that continue, in South America and Australasia, in Siberia and the US, in Australia, Africa and Canada. In all these places, there are indigenous groups who fight for their survival. The exiles from Eden, the nomads who roam the world looking for new places to settle, transform and control, must make common cause with these struggles.

15

Human activities have shaped the surface of much of the world. Farmers have effected the greatest changes, turning forests, deserts and swamps into fields and pastures. Hunter-gatherers have also shaped the world, but more subtly, intent on keeping it a place where wild plants, animals and fish can thrive. The displacement of hunters by farmers has meant less 'land' and more 'countryside'. These different ways of moving on the earth reflect the economies and societies of different kinds of human being.

The world is also shaped by stories. What people feel, know and need to pass on from generation to generation has existed in words: words that speak of how the world began, of how humans emerged in it and found both places to live and ways to deal with one another. Words are entitlement to these places. The stories of farmers, including the Creation as described in Genesis, give meaning to their ways of life. The stories of hunter-gatherers give meaning to theirs. These are different meanings, different kinds of stories. The history of the one has dominated and, to a large extent, silenced the other.

Many hunter-gatherer ways of knowing the world have disappeared, along with hunter-gatherer languages. These are rich and unique parts of human history that cannot be recovered. If the words are gone, so are the stories. A particular shape is lost forever. There are fears that hundreds more languages – many of them those of hunter-gatherers – will have disappeared within another generation. Each such case represents a harm that is inestimable: the cumulative loss of language constitutes a diminution in the range of what it means to be human.

There is, however, a story about these stories that has its own importance. The encounter between hunter-gatherers and farmers is a history of loss to one kind of society, gain to another. For hunter-gatherers, some losses cannot be compensated. But the story itself is one form of compensation. If the world can acknowledge who hunter-gatherers are, how they know and own their lands, what the encounter with farmers and colonists has meant, then some restitution can be made. An inquiry into the fate as well as the achievements of hunter-gatherers is, in this regard, part of a story that hunter-gatherers need to tell and have told. Without the hunter-gatherers, humanity is diminished and cursed; with them, we can achieve a more complete version of ourselves.

Notes

Full publication information for the sources cited in these notes is given in the references.

In addition to the specific sources I refer to in the notes that follow, I have received help and inspiration from a wide range of Arctic literature. Some of this has been popular and anecdotal, as in the case of the work of Farley Mowat (which some would say is more literary than anecdotal). I have drawn on detailed ethnography, especially in relation to the central and eastern areas of the Arctic. No fieldwork proceeds without a background of writing by others that sometimes shapes and sometimes contradicts one's own work.

There is, of course, an extensive literature dealing with many aspects of Inuit archaeology, ethnography and social organization. The work that gives a particularly wide-ranging but detailed account of Inuit life across the Arctic is that of Knud Rasmussen, who, as the child of missionaries in Greenland, grew up speaking Inuktitut, and who therefore, when he became an explorer and ethnographer, had the rare ability to speak to the peoples he met in their own language. The results of his epic expedition across the Arctic were published in the *Report on the Fifth Thule Expedition*. The work runs to several volumes; Kaj Birket-Smith wrote some, Rasmussen others. I have always found volumes 4, 6, 7, 8 and 9 most compelling; they include shamanic stories, poems and vivid accounts of Inuit elders as well as a wealth of ethnographic detail. (It should be said, however, that Rasmussen has been criticized for taking liberties with some of his sources and oddly failing to give Inuktitut versions of all the stories he includes in the report.)

Prior to Rasmussen's Thule expedition, two other Arctic ethnographers of great importance were Vilhjalmur Stefansson and Diamond Jenness. Stefansson wrote a great deal, but his book *My Life with the Eskimo* draws together much of his work in a very readable form. Also, his *Not by Bread Alone* is a remarkable exploration of Inuit (and other peoples') diets. Jenness's most important ethnography is *The People of the Twilight*, in which he describes his stay with the Copper Eskimo of the central Arctic. Jenness subsequently became an influential member of the Canadian administration of northern affairs, and was associated with plans for relocating Inuit farther south, where, he proposed, they would be able to take advantage of employment opportunities arising with new activity on the subarctic frontier. (Plans of this kind for the most part failed very quickly.)

1 In *Frontiers*, a book that looks at the web of intergroup conflicts that constitutes the early history of the southern African Cape, Neil Mostert gives many details about how both settlers and Xhosa herders thought about and behaved towards Khoihoi and San peoples. The quote I use is from comments made by John Ovington, master of the *Benjamin*, on seeing the Khoihoi of the Cape in 1693. The words of Pyrard de Laval, written in 1610, are also revealing: 'Of all people they are the most bestial and sordid… They eat … as do dogs … they live … like animals' (*Frontiers*, p108). The fate of Tasmania's hunter-gatherers is described in Mark Cocker's *Rivers of Blood*. See p115ff and p127 for the quotes I use.

The literature reveals many voices that concur in their suggestion that the 'savages' Europeans encountered during the early years of exploration and colonization were not quite human. Of course, many societies and nations dehumanize their enemies and competitors. Yet to say that men, women and children who have languages, beliefs, clothing, implements and art are nonetheless something other than human is both strange and troubling. When aboriginal women are also the objects of sexual desire and the bearers of colonists' children, the suggestion that they are not human appears to be as ridiculous as it is grotesque. All the more striking, therefore, to find it occurs in so much commentary by settlers and explorers as they arrived in new frontiers.

There are, of course, some counterexamples, among which are the observations in G. F. Lyon's *Private Journal* about the Inuit of the Igloolik area, whom he visited often when icebound in north Hudson Bay in the 1820s. Lyon was impressed in many ways by the people, whose snow-houses he visited, and who, in turn, visited Lyon's ship. Yet even in these sympathetic and seemingly accurate reports, there are troubling descriptions of the Inuit visitors' taste for sugar and salt and their reactions to liquor.

2 An account of the Las Casa/Sepulveda debate is given in Lewis Hanke's *Aristotle and the American Indians*. There is also an article on the subject in Thomas Berger's *A Long and Terrible Shadow*.

3 Mexica (or Aztec), Maya and Inca societies constituted the 'high civilizations' of the Americas. The Mexica world – including its use of human sacrifice – is described by Inge Clendinnen in her book *Aztecs*. Marvin Harris's *Cannibals and Kings* documents, and speculates about the rationales for sacrifice and cannibalism in the region. It is important to emphasize here again that Aztec society was very distant from hunter-gatherer modes of life.

4 Thomas Hobbes's famous dictum about life being 'nasty, brutish, and short' comes from his *Leviathan*, first published in 1651. For a compelling account of how the philosophical views of both Hobbes and John Locke related to the development of capitalism, see C. B. Macpherson, *The Political Theory of Possessive Individualism*.

5 Vico, writing in the 1740s, sought to create a philosophy of history and a theory of knowledge in which the artefacts of humans (from chairs to social and economic events) could be known with certainty – unlike the creations of God (i.e. the natural world), which could not thus be known. His speculations about a 'savage state' rather surprisingly include a theory about a transition from hunters to herders, representing a shift from 'bestial wandering' to a reliance on pasture. Vico's work is cited in Alan Barnard's essay 'Images of hunters and gatherers in European thought'.

The idea that human beings are born free and then enslaved by the evils of civilization is associated with Rousseau and the romantic tradition within the Enlightenment school of philosophy. But Hugo Grotius, the Dutch theorist of law, noted in the early 1600s that 'foragers' lived 'without toil', and Engels, writing in the 1880s, saw in hunter-gatherer systems evidence of both 'primitive communism' and matriarchy. In this regard, Engels's *Family, Private Property and the State* stands as a fascinating attempt to use anthropology as the basis for a social critique of 19th-century society. For a review of the history of this issue, see Alan Barnard, op. cit., pp375–383. Barnard also quotes Montesquieu's 1748 *De l'esprit des lois*; Hegel, writing in 1820; and Marx, writing in 1857 (pp378–379).

The question about where a theory of hunter-gatherer society (albeit not always thus named) arises in European intellectual history can perhaps be answered by examining the purposes such a theory may have served. In his paper 'On the origins of hunter-gatherers in seventeenth-century Europe', Mark Pluciennik of the University of Wales speculates about these purposes (see note 20).

6 Ralph Standish is quoted in Neil Mostert's *Frontiers* (p108). Mostert also quotes a Reverend Terry, who wrote in 1616 of the Khoihoi that they were: 'Beasts in the skins of men rather than men in the skins of beasts' (pp107–108). In fact, Khoihoi were pastoralists, relying on herds of fat-tailed sheep; early settlers, however, did not make a significant distinction in their judgement of degrees of human development between Khoihoi sheep herders and San (or Bushmen) hunter-gatherers. Mostert writes very compellingly of the relationships between early settlers – black and white – and the San, describing both the degree of dependence that settlers had on San knowledge and the low level of humanity to which the San were nonetheless consigned. He quotes the South African historian George MacCall Theal as representative of his time in observing that Bushmen habits 'were not much more elevated than those of animals', and that it was difficult to conceive of a human being 'in a more degraded condition' (pp31–32).

7 The Trudeau government's position on the place of Indians in Canadian society was first set out in a 1969 white paper, issued on the authority of the then minister for Indian Affairs, now Canadian prime minister, Jean Chrétien. The white paper argues that there should be a gradual ending of treaty rights of Indians, and that the dissolution of their reserves and related special status would be an appropriate and necessary form of development. This position caused outrage throughout the country's aboriginal communities, mobilizing a newly radical form of First Nation politics. The Calder case entered the courts in the same year, reaching the Supreme Court (after comprehensive defeats in the two lower courts) two years later. The shift in Trudeau's policy may be said to have resulted from the combined impacts of the new Indian politics and the Supreme Court judgement.

In fact, the Calder case was not the first such consideration of aboriginal rights in Canada. Its significance lay in the Supreme Court's split decision – the sign of a changing legal atmosphere. The sequence of events, and the uses of evidence, that determined this atmosphere are set out in Dara Culhane's *The Pleasure of the Crown* (see especially pp72–89). Culhane quotes the Canadian historian Peter Kulchyski, who has observed that the legal forum is a strange and even incoherent one for resolving issues of rights. Kulchyski comments that the history of the court cases is often one of 'losses and gains, of shifting terrain … a history where the losers often win and the winners often lose' (Culhane, p73).

8 The modern case that most clearly defined the test for aboriginal title and right in Canadian courts was *Baker Lake* v. *the Crown.* This case also led to a view that aboriginal people could only claim rights to resources they actually use. This created uncertainty about the question of resources people did not know about in their territories, for example, minerals, oil and gas. The judgment in Baker Lake suggested that if people did not know about their assets and were therefore not using them, they had no rights to them. The Delgamuukw case, which reached the courts in 1994 and was decided in 1997, has led to a redefinition of the tests, and recognizes much more of indigenous peoples' potentially inherent rights in all aspects of their territories, including the potential for development without reference to particular use. One of the issues that Degamuukw settled was the depth of time that evidence must show. It ruled that for title, the relevant date was 1846; for rights (i.e. use and resource, including fishing, hunting and gathering), the date should be time of first contact with Europeans.

The St. Catherine's Milling case of 1885 is an early judgment that has been brought to bear in modern land-rights cases. It is important because it speaks to which agency has the right to extinguish aboriginal title, the federal or provincial Crown. It also speaks to the consequences of extinguishment. It is not a case, however, that establishes a precedent for any protection of aboriginal rights or titles to either land or resources.

The earliest case that does address the nature of aboriginal rights, and which also bears on modern cases, was decided in Southern Rhodesia in 1919. Judgment in this case introduced the notion that you could have aboriginal people who roam and have no society, and therefore led to the requirement that native litigants show they have an organized society. It was here that the idea that human beings can be placed at different levels of an evolutionary ladder entered into modern jurisprudence, with the attendant notion that some peoples are so low on this ladder – as evidenced by their way of 'just wandering around' – that they have no rights to lands or resources. (See Dara Culhane's *The Pleasure of the Crown* for these and other cases, especially chapter 6.)

9 The 'organized society' test depends on the idea that some humans are not humans. This is social-scientific nonsense, of course, and originates in an attempt to justify expropriation on racial or cultural grounds. At the end of the 20th century this was given the name 'ethnic cleansing' – a new term for what many hunter-gatherers have long experienced.

10 Biologists spend a great deal of time testing the intelligence of many species, from rats and pigeons to chimpanzees and parrots. Many forms and levels of intelligence are described as a result of this research. But biologists who assess the achievements of animals in experimental tests, or measure their speed and effectiveness at learning new skills, are not creating models of internal linguistic abilities. It may be that some human actions that we believe arise from consciously made decisions, processed in language, are more directly controlled by our genetic hard-wiring than we would like to admit – though this is an area of ongoing contention. The central point is that what happens with language, and therefore in the mind, pertains to a uniquely human form of intelligence.

11 The observation on apes is from Derek Bickerton's *Language and Human Behaviour*, p7. The quote about noises from our mouths is from the first page of Steven Pinker's *Language Instinct*.

12 A question arises in relation to the spread of humans across the world: what was the process that resulted in so many *different* languages? Linguists have identified correlations between the length of time a society is isolated from its neighbours and the evolution of a distinct language. By analysing vocabulary and grammar, it is possible to analyse links between peoples and even sequences of movement. The human geographer James L. Newman has suggested that farming, by causing people to settle in scattered but definite places, increased the degree of isolation between communities. He uses this to explain the multiplicity of agricultural languages in, for example, much of Africa (see his *Peopling of Africa*, especially p4).

Obviously hunter-gatherers settled in large territories giving rise to a language map with accordingly large areas in which people speak the same language. But where one hunter-gatherer society's territories meet those of another hunter-gatherer society, languages differ – sometimes at the level of dialect, sometimes at the level of language family. The boundary between Athabaskan and Algonquian speakers in subarctic North America, for example, suggests deep conservatism with regard to language, despite closely related economic systems. Similarly, a map of languages for the North Pacific Coast would show great varieties of languages in relatively small regions. The region that came to be California once contained approximately 80 different aboriginal languages. By comparison, the spread of Indo-European languages is a homogenizing process resulting from farming. It may be that when it comes to the variety of human languages, Newman has attributed to agriculturalists some of the features of hunter-gatherers.

13 The quote comes from Desmond Clark of the University of California at Berkeley. It is cited in a summary of the findings pertaining to *Homo erectus* and language in Robin McKie's *Ape/Man* (pp82–84). McKie reviews the evidence for the links between language and *Homo Heidelbergiensis* on pp122–124. In fact, the evidence he gives of humans who probably had language comes from European sites. Much related evidence argues strongly in favour of the view that these language users in Europe came from somewhere in Africa, and that their dispersal was itself a result of speech. This means that the date of *Heidelbergiensis* is a very late date to use in pinpointing the beginnings of language. The matter remains unresolved, but it would seem reasonable to say that our ancestors made the evolutionary step necessary for language at least 1 million years ago.

14 The process by which human beings acquired language is bound to involve speculations about the nature of evolution, the structure of the human brain and the functional advantages of language itself. The science that pertains to these things is constantly evolving. An account of the evidence, and the state of the relevant scientific art, is to be found in Steven Pinker's *Language Instinct*. Pinker reviews the results obtained by experts who have attempted to teach apes to use language (see pp335–349), revealing how unsuccessful these attempts ultimately are as language learning, then considers evolution and the probably development of a hard-wired faculty for language in human brains (p349ff). On the question of how long it took for humans to evolve language, he notes: 'We expect a fade-in, but we see a big bang' (p343).

15 Anthony Traill made the observation that San speakers are 'the acrobats of the mouth'. His essay '*!Khwa-Ka Hhouiten*, The Rush of the Storm' offers many insights into both the nature of San Language and the causes of language loss. I am grateful to the ethnolinguist Nigel Crawhall for details about the sound elements in different languages (personal communication, 1999).

16 Noam Chomsky's work on language began in the 1950s and continued into the 1970s. The quotes here come from *Reflections on Language*. These passages are quoted at greater length in Steven Pinker's *Language Instinct*, pp22–23.

17 This issue is discussed in Steven Pinker's *Words and Rules* (p198), where he cites the work of Arnold Zwicky, James Morgan, Lisa Travis, J. Tooby and Irven DeVore. For Pinker's comments on grammar learning and identical twins, see *Words and Rules*, p203. For Pinker's concluding remarks, see p210.

18 Lévi-Strauss first wrote about the Nambikwara in the 1940s. He contributed an essay to volume 3 of the 1948 *Handbook of South American Indians*. The first edition of *Tristes Tropiques* was published in 1955; it was translated into English as *A World on the Wane*, first published in 1961. *The Savage Mind* (*La Pensée Sauvage*), published in French in 1962 and in English in 1966, is the book of his that had the most widespread impact on European intellectuals. Lévi-Strauss's work on kinship and totemism, especially *Les Structures elémentaires de la parentée* and *Totemism*, published in 1962 and 1963, respectively, examined core questions of anthropology.

19 The Lévi-Strauss version of the myth, which takes place in the Nass Valley in Nisga'a territory (though Lévi-Strauss identified it by the broader term Tsimshian, now used to refer to the language family of the region), was drawn from written accounts. His analysis of the myth, 'The Story of Asdiwal', was published with an accompanying essay by Edmund Leach, in which Leach gave himself the task of explaining and celebrating structuralism to English anthropologists. Neither Lévi-Strauss nor Leach ever did fieldwork in the region.

20 In his paper 'On the origins of hunter-gatherers in seventeenth century Europe', Mark Pluciennik of the University of Wales suggests that the new science of political economy divided human society into hunters, herders and farmers as part of a need to rationalize and justify individualism, inequality and the unquestionable obligation of labour. Natural laws were sought that would show that certain kinds of individual owed service to society but could not expect to be an equal member of it. Pluciennik suggests that the purported 'laziness', 'ignorance' and 'inferiority' of 'savages' was useful to this project because it laid a 'natural' foundation for hierarchy and the possibility of fundamental differences among people.

He also suggested that these categories – hunter, herder and farmer – are contingent and heuristic: they were invented to meet a particular intellectual and political need, and are not grounded in sociological or anthropological reality. A difficulty with this reductionist account of the categories lies in the extent to which they are to be found in other languages and times. At the Cambridge conference where Pluciennik put forward his view that the categories belonged to 17th- and 18th-century social theory, not to reality, James Woodburn pointed out that the same categories are to be found in the Bantu languages of southern Africa, with a provenance far from the political economists of 17th-century Europe. Woodburn also observed that these categories correspond to what people can most readily observe. Hence it is not surprising to find that a distinction between hunter-gatherers and the herders or farmers who are their neighbours is of great importance to both the hunter-gatherers and the agropasturalists themselves.

21 The history of peasant life in Ireland has yielded a number of 'traditions'. In reality the domination of peasant families by landlords seeking to maximize rents created the Ireland that is most often said to be 'traditional'. This is the peasant life described in Conrad Arensberg's *Irish Countryman*, then in Conrad Arensberg and Solon Kimball's famous *Family and Community in Ireland*. This particular peasant society, whose features made it so vulnerable to potato blight, developed in the period between 1700 and 1850. An ancient Irish society, reaching back to Erse myths and the 'golden age' of Irish ruling families, was destroyed by British invasion, beginning in the 13th century and ending with Cromwell's conquest of Ireland in the mid-17th century. I discuss Arensberg and Kimball's sociology in *Inishkillane*, pp4–7.

The literature of Ireland is not to be reduced, of course, to a reflection of any single aspect of Irish (or any other) history. Yet there is a connection between the moods of much Irish writing and the successive transformations and disasters in the history of the country's peasantry. This idea is something I use throughout the text of *Inishkillane*, setting literature alongside sociology.

22 James Woodburn's summary of attitudes to hunter-gatherers in southern Africa is in his essay 'Indigenous Discrimination'. There Woodburn details a set of negative attitudes that their neighbours appear to hold towards hunter-gatherers, then goes on to identify reasons for the discrimination. This includes the *appearance* of hunter-gatherers in the eyes of agriculturalists or pastoralists, with a related identification of hunter-gatherers with the wild, and the apparent absence among hunter-gatherers of institutions of authority and social control. Woodburn also cites evaluations of hunter-gatherers that are ambiguous or even positive, identifying the extent to which they are believed to have exotic powers; but he adds a fascinating observation about the extent to which in Africa and many other places, 'there is a fear that those who are weak and impotent have mysterious supernatural powers which threaten those who exercise power. Power holders tend to be ambivalent about their right to power, wealth and prestige and they fear that resentment of those who lack power, wealth and prestige may mysteriously threaten their health, well-being and prosperity.' He adds that hunter-gatherers can, at times, use this fear to redress some of the political imbalance between themselves and others. Other writing by James Woodburn that bears on these issues includes the introduction he co-authored with Alan Barnard to *Hunters and Gatherers* and his essay 'Egalitarian Societies'.

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4

Environmental and Health Benefits of Hunting Lifestyles and Diets for the Innu of Labrador

Colin Samson and Jules Pretty

Background to the Sedentarization of the Innu

The Innu are Algonquian-speaking people of the Labrador-Quebec peninsula. For some 8000 years, they and their ancestors were permanent nomadic hunters ranging over an area the size of France. In the boreal forests and tundra of the interior of the peninsula they hunted caribou, including the vast George River herd, as well as bear, marten, lynx, fox, beaver, otter, muskrat, partridges, ptarmigan, ducks, geese, several species of fish and occasionally seals in the coastal bays. Archaeological evidence suggests that the ancestors of the Innu also had a maritime element in their economy and that the ancestors of the Innu moved inland to concentrate on caribou hunting following Inuit expansion to the Labrador coast around 1300 (Loring, 1997, 1998; Loring and Ashini, 2000; Loring et al, 2002).

But from the 1600s onwards, the Innu way of life was gradually reshaped following contact with European colonists and by subsequent pressures placed upon it by missionaries, fur traders and the Canadian state (Leacock, 1954, 1995; Henriksen, 1973; Samson, 2003a). In the mid 20th century, the Indian Act was implemented in Quebec and those Innu coming to trade at the various posts, which eventually became villages, were registered and officially regarded as domiciled there. In Labrador, the focus of this study, the provincial authorities initiated an aggressive assimilation campaign soon after Newfoundland joined the Canadian confederation in 1949. This resulted in the sedentarization of Innu hunting families in the late 1950s in the village of Sheshatshiu, on the opposite shore to the North West River trading post on Lake Melville in Central Labrador, and in Davis Inlet (or Utshimassits) on Iluikoyak Island, across from the old Davis Inlet trading post on the north Labrador

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coast in 1967. Davis Inlet is now abandoned following a further relocation of the Mushuau (or 'tundra') Innu to Natuashish on the mainland in 2003. Today, there are some 18,000 Innu in Labrador and Quebec, of whom some 2100 live in the two villages in Labrador (Indian and Northern Affairs Canada, 2005a, 2005b).

Sedentarization inevitably undermined the relationship of the Innu to their hunting culture, because mobility was central to its efficiency (Loring, 1997, p198) and the land provided the basis for their social, economic and religious ideas and practices. As with other indigenous people across North America, 'breaking the Indian relation to the land had concrete as well as symbolic significance' (Rogin, 1987, p155). The vast interior of Labrador-Quebec suddenly became free of mobile populations. Severing the relationship between people and land was then an important precursor to natural resource exploitation and extraction for timber, energy and minerals (Samson, 2003a, pp86–96). In addition, placing the Innu in villages also had vast symbolic value, as the authorities saw it as a measure of their integration into Canadian society. At the centre of the sedentarization project was the conversion of the Innu not simply to Christianity but to a Western and modernist worldview. Formal schooling was central to the goal of making Innu think more like Canadians and, it was thought, eventually helping them accept the change from subsistence hunting to lives of paid wage labour.

However, to date no reliable source of wage labour has been found for the Innu, and most families survive on welfare payments. With the exception of a few individual political leaders, Innu are at best peripheral to all decisions about economic development and the environment in Labrador. Most employed Innu work in the government-created institutions of the villages. Only a handful work in Goose Bay or in resource extraction industries, such as the Voisey's Bay mine, 75km north of Davis Inlet. These latter jobs primarily offer sporadic and temporary employment. Similarly, experiences of the Innu around Bersimis (Charest, 1982, pp421–422) and Schefferville, both in Quebec, indicate that only a handful were employed in hydroelectric and mining projects respectively, and then only at low levels on below-average salaries.

Instead of employment, sedentarization has been accompanied by an increase in heavy drinking, suicide, solvent abuse and sexual abuse (Samson et al, 1999; Samson, 2003b). Ironically, much of the employment for the Innu is now in non-professional jobs in clinics, homes, shelters and treatment programmes in the villages. The advent of village-based social pathology among peoples immersed in what had hitherto been a relatively stable and mobile society is similar to changes recorded in other northern native communities subject to similar pressures (Brody, 1981; Bussidor and Bilgen-Reinart, 1997; Boothroyd et al, 2001; Inuit Tapiiriit Kanatami, 2004). Sedentarization policies, motivated by a mixture of desires to assimilate mobile groups and clear lands for agriculture and resource extraction, have occurred in many other places, including Australia (Trudgen, 2000; McKnight, 2002), Botswana (Gall, 2002; Olmsted, 2004) and Mongolia (Humphrey and Sneath, 1999) with similarly negative consequences for the populations involved. The loss of self-esteem, manifested in ubiquitous alcohol abuse, child gas sniffing and suicides, has had a profound effect on the Innu and their way of life. More than two decades ago, Brody (1981, p72) described the pathology of similarly situated aboriginal communities elsewhere in Canada: 'many northern reserves appear to be grim and even hateful little places, clusters of houses crowded together by planners in order to achieve economies of administration and services… Such compression of a people distinctive for their free roamings through unbounded forest is bizarre and painful.'

The feeling of loss experienced by the Innu is bound up with a tension that has built up between the past life in the country and the present life in the villages. The nomadic hunting way of life is often regarded as strenuous and sometimes demanding to the point of life-threatening, but it is healthy, vibrant and connects people to a core of their cultural and environmental identity. Typically, hunting families are spread out across a vast expanse of territory, and so have little aggregate impact on resources. Settlements, on the other hand, are seen as permeated by misery created by alcohol, sexual abuse, family rivalries, boredom and the physical confinement to a relatively small area. Because the village is now the site of so many recent personal tragedies the feeling of loss is magnified, especially among the generation that have known both country and village life. The remarks of Kanikuen Penashue, a resident of Sheshatshiu, are typical: 'the problem is that we are so scared because the things that exist today are not explainable. They are so new to us. The whole world changed right under our feet. We are lost.' (Innu Nation and Mushuau Innu Band Council, 1993; see also, Innu Nation and Mushuau Innu Band Council, 1995, pp24–41). Local settlers at North West River have also observed a change in the Innu from their confidence and generosity in the country to their trauma and suspicion of whites after sedentarization (Plaice, 1990, pp74–87).

The primary response of the Canadian government has been to fund village-based solutions such as medical and quasi-medical establishments, emergency medical evacuations to Newfoundland, and housing, sports and building infrastructure (especially for alcohol programmes, clinics and homes). The relocation of the Mushuau Innu from Davis Inlet, where they endured life in shacks without sanitation and running water from 1967 to 2003 to the new C$152 million village of Natuashish can also be seen as part of these efforts (Indian and Northern Affairs Canada, 2005b). The Labrador Innu Comprehensive Healing Strategy implemented by the Canadian government is almost entirely 'community-based' (see Treasury Board Secretariat, 2004). Despite these efforts, social pathology has continued to worsen since the move with four suicides in the first year and with the discovery that 35 per cent of students at the Natuashish school suffered from Foetal Alcohol Syndrome (Philpott et al, 2004). While some government policy reactions to the visible health crisis among the Innu have been welcomed, by ignoring the importance of Innu connections to the land, they fail to address some of the root causes of that crisis.

Our objectives in this paper are to examine the biological and environmental underpinnings of this crisis, and use them as a basis to show how country-oriented solutions might offer more hope of stemming the physical, psychological and cultural decline of the Innu. We make our case for a country-oriented shift in policy by arguing that two transitions have been fundamental to recent Innu history.

Firstly, a nutrition transition can be discerned in the abrupt shift from consumption of wild foods to processed foods. This is paralleled by a physical activity transition, from regularly active and strenuous exercise to much less demanding set of activities in the village. We investigate these transitions through both historical sources and interviews with Innu, and then explore how such changes have impacted upon health. We also compare nutritional properties of country foods with those of foods consumed in the village, as well as compare activity patterns in the country and in the village. We then use medical and environmental data to examine how the new junk food diets and lack of exercise are affecting the health of the Innu. Finally, we look at how practical policy changes and economic activities such as those being promoted by the Tshikapisk Foundation (2004), an association of Innu hunting families, could be put into effect to restore hunting activities and address some of the manifold health problems of the Innu. The research is based on the fieldwork of one of the authors (CS) with the Innu since 1994, and joint research since 2002, involving interviews, observations and data collection in Sheshatshiu and in the country at Kenemau.

The Nutrition Transition

The indigenous relationship with the land

A key to understanding the crisis of the Innu lies in setting their recent experiences in the villages in contrast to their historical and continuing connections with the land. In the country, the Innu experience daily connectedness and respect for nature, and the closeness of families and communities. When Innu look at the country, they do not just see animals, trees and water. Like many other indigenous peoples, they see places with stories, they locate events, they see ancestors wandering the land, they see past and present intimately linked, they see tracks and signs, and nature tied together with them (Brody, 1981; Lopez, 1986; Basso, 1996; Cruikshank, 1998; Nuttall, 1998; Posey, 1999; Clayton and Opotow, 2003; Folke, 2004). But when Canadian and Newfoundland policy makers turned their attentions to Labrador, they instead saw the economic value of timber, of reservoirs for hydroelectricity, of iron ore and nickel in the rocks, and of the wildlife that needed protecting (Samson, 2003a, pp96–111).

This core difference in values is critical. For the Innu, to destroy a part of a connected system is eventually to undermine the whole. In the country, the Innu feel they have much greater autonomy and freedom. They are able to choose when to hunt and when to rest. Their decisions affect the land and its resources, and their knowledge accrued over hundreds of generations of observation and experimentation determines their success. By contrast, life in the village is quite different. Because the economy required to support wage labour never materialized as the provincial authorities had earlier promised (Samson, 2003a, pp96, 142–147), there are few secure jobs for Innu, and thus a dependence on welfare has emerged with little opportunity for self-reliance or self-determined life choices. A significant component of this change involves food. In the country, the Innu were self-reliant in providing for their sustenance. Contacts with missionaries and traders brought firearms, tea, flour and tobacco, but because they were relatively autonomous until sedentarization, the Innu diet largely consisted of wild meat, fish, waterfowl and berries (Samson, 2003a, pp127–142).

The transition to processed foods

The nutrition transition is a well-established phenomenon in both industrialized and developing countries (Popkin, 1998). In almost all of these industrialized and developing country contexts, people have been largely dependent on the produce from agriculture for several thousand years, and the nutrition transition has involved a change from one diet based largely on foods from domesticated crops and animals to another with similar derivation but with increased processing. For the most recently settled hunter-gatherer societies, such as the Innu and other indigenous peoples of Canada, their transition has occurred directly from wild foods to modern refined (and often junk) foods.

In the Arctic and Subarctic regions, indigenous peoples' diets have changed from foods that are typically nutrient-dense, with high levels of protein and fat (especially omega-3 fatty acids), and vitamins and minerals (e.g. vitamin C, selenium), but relatively low levels of carbohydrates, to diets high in carbohydrates and saturated fats and low in essential nutrients (McGrath-Hanna et al, 2003, pp230–231). Importantly, these changes are on the whole very recent, with northern peoples such as the Innu and Eastern James Bay Cree (Delormier and Kuhnlein, 1999, p182) still engaged in some hunting activities while domiciled in villages. Hence, their diets consist of both country and modern, largely processed, foods. While country foods can remain a significant part of the sustenance and nutritional intake of some northern peoples, the diet that has become the norm over recent decades is one that is deficient in many of the healthy properties of food. A survey of seven northern aboriginal communities in the 1990s characterized this pattern as being low in fruits, vegetables and dairy products, high in sugar, fat and saturated fat, and consisting of intakes of calcium, magnesium, folate, vitamin C and vitamin A that do not reach recommended doses (Lawn et al, 2002, p10).

Amongst Innu *Tshenut*, there is a widespread view that store bought food is both unhealthy and makes people ill. This was evident almost as soon as the Innu were sedentarized in the 1950s and 1960s when Father Frank Peters (1972, pp10–11) quoted Innu at the new Davis Inlet village as feeling hungry after eating processed food, and feeling that chicken, pork and beef were not as substantial as caribou meat. At the same time, he also noted the rapid deterioration of the teeth of the population, a condition he attributed to the sudden availability of sweets and soft drinks in the store. Other observers noted exactly the same unfavourable comparisons being made between store and country food at the time (Henriksen, 1977, p4), and as late as the 1990s, many Innu believed that the foods in the store were also adulterated, stale and unsafe to eat (Innu Nation and Mushuau Innu Band Council, 1995, p39). By contrast, a visiting physician reported that people in the country were remarkably healthy, with very few cardiovascular or lung problems, and good dental health (Sarsfield, 1977). The major causes of mortality were trauma from accidents and infant illnesses.

These observations of the worries Innu had about store food in the early days of Utshimassits are backed up by the reminiscences of people who remember the times of transition from permanent country living to semi-sedentary village life. Some believed that their children would starve because store food is not as good for them as caribou, beaver and porcupine (Elizabeth Penashue, interview, 1994). Others observed high numbers of children getting sick in the community (Shimiu Penashue, interviewed 1995) and other Innu maintain that the food purchased in the stores does not taste good (Pien and Lizette Penashue, interviewed 1997). These sentiments were shared by Mary Adele Penashue (interviewed 2003), who remarked, 'I have strange feelings when I'm in the house eating store-bought food… It's making us sick and weak, this fast food' Despite these views, store-bought processed food has become increasingly dominant in the diets of Innu in the villages, and is starting to be preferred by the younger generations.

Nutritional content of country and store foods

Once there has been a lifestyle change brought about by sedentarization, then indigenous people have no constant access to country food throughout the year, and so come to rely on store-bought food derived from distant agricultural systems. This becomes a health problem as hunted and gathered foods are very different in nutrient content and density than store-bought foods. Table 4.1 shows the energy, protein, fat and key vitamin content of eight types of wild meat and fish compared with eight domestic meats available in local shops. These data show energy and protein levels similar to those measured *in situ* for the Cree (Berkes et al, 1995). Table 4.2 contains details of the recommended daily allowances (RDAs) for adults and children, and shows that RDAs for minerals, vitamins and energy can be reached with relatively modest quantities of country foods.

For this sample of 16 foods, store food has 75 per cent more energy content than country food (1.26MJ $100g^{-1}$ compared with 0.72MJ $100g^{-1}$), 37 per cent less protein (20.9g compared with 28.7g), and more than four times as much fat (23.2g compared with 5.7g), of which 8.7g are saturated fats. These saturated fats are known to be an important risk factor in coronary heart disease and also contribute to the addition of body fat.

Country foods also contain more iron (4mg $100g^{-1}$ compared with 1.68g in store foods). Iron deficiency is now a recognized problem for an increasing number of mothers and children worldwide following the adoption of modern diets (ACC/SCN, 2000). There is more than three times the vitamin C in this sample of coun-

Table 4.1 *Nutrient content for wild and store foods*

Food	*Energy (MJ 100g^{-1})*	*Protein (g 100g^{-1})*	*Total fat (g 100g^{-1})*	*Saturated fat (g 100g^{-1})*	*Iron (mg 100g^{-1})*	*Vitamin C (mg 100g^{-1})*	*Thiamin (mg 100g^{-1})*	*Riboflavin (mg 100g^{-1})*	*Niacin (mg 100g^{-1})*
Caribou	0.69	29.8	4.42	1.70	6.17	3.0	0.25	0.90	5.8
Pheasant	1.03	32.4	12.10	3.50	1.43	2.3	0.07	0.18	7.5
Beaver	0.89	34.9	6.96	2.10	10.00	3.0	0.05	0.31	2.2
Rabbit (wild)	0.72	33.0	3.51	1.10	4.85	0.0	0.02	0.07	6.4
Moose	0.56	29.3	0.97	0.29	4.22	5.0	0.05	0.34	5.3
Duck	0.51	19.9	4.25	1.32	4.51	6.2	0.42	0.31	3.4
Salmon	0.77	27.4	7.50	1.59	0.71	1.0	0.12	0.16	7.8
Trout	0.63	22.9	5.80	1.52	0.38	2.0	0.15	0.09	5.8
Average for country foods	0.72	28.7	5.69	1.64	4.03	2.8	0.14	0.30	5.5
Luncheon meat	1.40	12.5	30.3	10.8	0.72	1.0	0.37	0.19	3.1
Bologna beef/pork	1.27	15.2	24.6	9.7	1.21	0.8	0.22	0.19	2.5
Pork loin chops	1.03	27.9	14.5	5.3	1.05	0.9	0.77	0.22	4.6
Beef, braised	1.43	26.9	25.7	10.2	3.04	0.0	0.07	0.23	2.5
Steak	1.07	28.0	15.2	6.1	3.04	0.0	0.10	0.27	3.9
Beef corned	1.04	26.9	15.2	6.2	2.10	0.0	0.02	0.14	2.4
Beef/pork frankfurter	1.34	11.1	28.9	10.7	1.10	0.0	0.20	0.11	2.7
Pork sausage	1.54	19.2	30.8	10.8	1.15	3.8	0.73	0.27	4.6
Average for store foods	1.26	20.9	23.2	8.7	1.68	0.81	0.31	0.20	3.3

Source: USDA National Nutrient Database, 2003; Gebhardt and Thomas, 2002

Table 4.2 *Recommended daily dietary allowances of key nutrients, minerals and vitamins*

	Energy (MJ)	Protein (g)	Iron (mg)	Vitamin C (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)
Children 1–10 years	7.11	24	10	20	0.55	0.55	7
Males							
11–18	11.50	52	12	60	1.1	1.1	14
18–50	12.12	61	10	90	1.2	1.3	16
> 51	9.61	63	10	90	1.2	1.3	16
Females							
11–18	9.20	45	15	55	1.0	1.0	13
18–50	9.20	48	15	75	1.1	1.1	14
> 51	7.95	50	10	75	1.1	1.1	14

Note: RDAs contain safety margins, and do not represent the level at which deficiency symptoms might occur. These are lower than the DRIs (dietary reference intakes).
Source: Gebhardt and Thomas, 2002

try foods, 50 per cent more riboflavin, 67 per cent more niacin, though less than half the thiamine. These high concentrations of vitamins in country foods are important for hunters such as the Innu with little or no cereals or vegetables in their traditional diets. Some country foods are very high in certain vitamins – ptarmigan, for example, has ten times as much niacin than other meats and fish (Mackey, 1987), and caribou and duck are high in thiamin. A variety of berries are important sources of vitamin C, even though only relatively small amounts are consumed as a result of the short growing season. Clearly, these country foods were once able to supply the necessary macro- and micro-nutrients to ensure adults and children remained healthy over thousands of years.

How do these foods compare with a typical 'junk' food meal of the sort now increasingly available to the Innu and other indigenous peoples? One typical meal of a cheeseburger with French fries, each of some 170g in weight, would supply 52g fat (of which 16g are saturated), 31g of protein, and a total of 4.29MJ (35 per cent of the daily recommended total for adult males and 47 per cent for women). By contrast, a 340g meal of caribou meat would supply 15g of fat (of which 5.8g are saturated), 101g of protein, and 2.37MJ (20 per cent of male and 26 per cent of female RDAs). A similar meal of salmon provides 25g of fat, 93g of protein, and 2.62MJ of energy, and of beaver 23.7g of fat, 119g of protein, and 3.01MJ of energy. The nutritional value of hunted, fished and gathered foods is magnified still further because almost all edible parts of foods are consumed by northern peoples. With the caribou, for example, all the organs are eaten, as well as bone marrow, both of which provide important sources of fat from an animal that is typically very lean (Tracy and Kramer, 2000, p48).

A variety of studies of indigenous groups across the Canadian Subarctic have recorded how much country food is consumed after the lifestyles of aboriginal peoples were shifted from being nomadic to settled. These vary from a low of 52kg per person per year in Manitoba communities, to 96kg yr^{-1} for Inuit in Labrador, 115kg yr^{-1} for the James Bay Cree, 146kg yr^{-1} for Omushkego Cree in Ontario, 221kg yr^{-1} for groups in the Keewatin region, and 285kg yr^{-1} for the Inuit of north Quebec (Mackey and Orr, 1987; Wein et al, 1991; Berkes et al, 1995a). These amount to a daily consumption of between 140g and 781g of country food. Some 200g of country food supplies the recommended daily protein requirement for adult males, while 175g is sufficient for adult females (see Tables 4.1 and 4.2). Clearly, continuing to consume country food will be good for the physical health of Innu and other northern peoples. The hunter-gatherer nutritional regime is the oldest human diet and is well-suited to human physiologies (Eaton and Eaton, 1999, p449).

The decline in country food consumption

Country foods still remain a part of the diets of the Innu and other northern peoples. Among the Cree, for example, 29 species of wildlife are still eaten, each with 2–11 edible parts, with fish and birds the most consumed in summer, and large and small mammals the most important in winter (Delormier and Kuhnlein, 1999). During summer, about half of the fat consumed by women comes from country foods, with Canada goose the most important single source (14.3 per cent). In winter, though, only one of the top 20 sources of fat was a country food (goose again), with the top source now french fries (9.6 per cent of total fat). Among the Cree, Chipewyan and Metis peoples around Buffalo National Park, Wein et al (1991) estimated that households ate country foods six times per week during the late 1980s.

Wagner's (1986) study of ten reserve communities in Manitoba indicated that the harvest size and diversity of country foods depended on the local availability of wildlife habitats and cultural preferences. Harvests were greater in the more sparsely populated northern communities. By comparing documented records for 1912–1914, it was clear that consumption of country foods had declined (Table 4.3).

Table 4.3 *Changes in annual household consumption of country foods between 1912–1914 and 1983–1984*

	Central Quebec 1912–1914 *(numbers of each animal; fish in kg)*	**Manitoba 1983–1984** *(numbers of each animal; fish in kg)*	**Changes (%)**
Moose	0.8	0.54	–32.5
Caribou	2.5	0.07	–97.3
Beaver	94.3	5.6	–94.1
Muskrat	70.5	23	–67.4
Black bear	4.5	0.03	–99.4
Rabbit	5740	3	–99.9
Duck	135	15	–88.9
Fish (kg)	7215	78	–98.9

Source: Wagner, 1986

Using a caesium tracing method, Tracy and Kramer (2000) found that caribou consumption in northern Canada had declined by 80 per cent in 11 communities from 183g day^{-1} in 1967–1968 to 35.1g day^{-1} in the 1990s.

Similar declines in country food consumption have been recorded amongst the Inuit of Greenland (Pars et al, 2001). In the north-west, country foods (including here seal and whale) provided 54 per cent of daily energy intake in 1952, but this had fallen to 25 per cent by 1991. Once again, younger people consume fewer country foods, as do those in households resident in larger towns compared with those in villages. The youngest group consumed the most soft drinks, fruit syrups, and fruit and vegetables. Most studies have found that young people now consume less country food than elders (Wein et al, 1991; Tracy and Kramer, 2000, p46), and that there have been declines in consumption over time. Delormier and Kuhnlein (1999) found that there had been a decline in use of traditional foods among the Cree of Quebec, particularly by the younger generation. Berkes et al (1995a, 1995b) found similar changes amongst the Cree of northern Ontario. An Indian and Northern Affairs Canada (INAC) nutrition survey (Lawn et al, 2002, p4) found that among adults over 45 in Inuit communities in Nunavik (northern Quebec) about a third of energy was obtained from country foods, compared with only 22 per cent among younger women and 18 per cent among younger men. Older people were also reported to be eating much less junk food than their younger counterparts.

There are few data on changes in consumption of country foods by the Innu over time (Usher, 1976; Mackey and Orr, 1987). Usher (1976) found that the major source of food and income in northern Labrador came from harvesting country foods. In the 1980s, Mackey (1987) indicated that 30–65 per cent of the Innu in Labrador continued to spend the autumn and/or spring months in the interior hunting, trapping, fishing and gathering. This has fallen dramatically since the withdrawal of funding for the Outpost programme, which enabled Innu families to spend several months a year in the country.

Health consequences

Changes in diet have had severe and costly public health consequences in most industrialized countries (CDC, 1996; Ferro-Luzzi and James, 2000; Eurodiet, 2001; Nestle, 2002). One of the most serious consequences of poor diet is the emerging obesity epidemic, the costs of which are some US$117 billion per year in the US, compared with US$97 billion for smoking (Kenkel and Manning, 1999). The Eurodiet (2001) study has also concluded that disabilities associated with high intakes of saturated fat and inadequate intakes of vegetable and fruit exceed the cost of tobacco use. It is further acknowledged that sedentary lifestyles are a major public health problem.

However, unlike most Europeans and North Americans, the Innu are still fortunate enough to have wild foods at their disposal in the vast Labrador-Quebec interior. A wide range of country foods are still consumed by all indigenous peoples in Canada, with more than 50 species of animals and birds regular in diets, including caribou, moose, rabbit, muskrat, beaver, porcupine, muskox, squirrel, lynx, fish, duck, geese, ptarmigan and grouse, together with a variety of fish, marine mammals, berries, wild rhubarb, wild onions and Labrador tea (Mackey and Orr, 1987; Berkes et al, 1995a; Wein et al, 1996). While northern peoples have been consuming these foods, the incidence of obesity, diabetes and cardiovascular diseases has been relatively low. It has been suggested that this is partly due to the high content of omega-3 fatty acids and antioxidants in the traditional diet (McGrath-Hanna et al, 2003, p230).

Although one facet of the changes occurring among northern indigenous peoples should never be taken in isolation, the public health consequences of new diets are now known to be serious contributors to a wide range of ailments. Some health problems arise from nutritional deficiencies of iron, iodide, folic acid, vitamin D and omega-3 polyunsaturated fatty acids, but most are due to excess consumption of energy and fat (causing obesity), sodium as salt (high blood pressure), saturated and trans fats (heart disease) and refined sugars (diabetes and dental caries). Diet is thought to be a factor in 30 per cent of cases of cancer in developed countries (Riboli and Norat, 2001).

While degenerative diseases such as diabetes, coronary heart disease and cancer have been relatively rare in hunter-gatherers, they are now becoming common among hunting peoples who have been sedentarized. As well as more energy expenditure and lifestyles that are more protective of the body (for example, the shorter gap between menarche and childbirth among hunter-gatherers protects against breast cancer), hunter-gatherer diets are composed of foods that are denser and more fibrous, have a high protein-to-fat ratio and lack the high amounts of sugar, salt, saturated fats and high calorie counts characteristic of many diets of people in industrialized societies. There is, therefore, much to learn from the qualities of the hunter-gatherer diet and lifestyle in terms of health promotion (Eaton and Eaton, 1999). Analysing broad epidemiological changes over time, McKeown (1988, p37) has found that diseases such as cancer, obesity, diabetes, hypertension and heart disease, as well as non-communicable diseases, are uncommon in hunter-gatherers and peasant agriculturists, appearing only when traditional ways of life are abandoned or disturbed.

Amongst Native North Americans, the result of the transition has been a rapid increase in recent years in diet-related health problems, particularly of type II diabetes, coronary heart disease and obesity (Thouez et al, 1990; Hegele et al, 1997; Story et al, 2003). This follows significant advances in reducing infant mortality, such as from 150 per 1000 live births amongst the Inuit in mid 20th century to 10 per 1000 towards the end of the century (Young, 1994). One study of Cree women in Quebec found 30 per cent with a BMI (body mass index in kg m^{-2}) of 25–29.9, and 57 per cent in the obese category of a BMI of more than 30kg m^{-2} (Delormier and Kuhnlein, 1999). Fifty per cent of the 36 women surveyed in Davis Inlet in 1992 had a BMI of greater than 30 per cent and 75 per cent of these women exceeded a BMI of 27 per cent, making Mushuau Innu women, according to these measures, the most obese of all the seven northern aboriginal communities surveyed by the INAC study (Lawn et al, 2002, p44). These are problems shared by many circumpolar peoples (McGrath-Hanna et al, 2003), and this extends to indigenous peoples across North America. Story et al (2003) suggest that 'obesity is now one of the most serious public health problems facing American-Indian children'. Hovering at an average of 25 per cent, the rates of obesity among aboriginal populations in Canada are almost twice that of Canadians as a whole (Canadian Institute for Health Information, 2004, p116).

As well as the adverse effects on physical health, there is also evidence that the change in diets for indigenous peoples may be implicated in the high rates of mental health problems suffered by these populations in recent years. Based on an extensive review of literature, McGrath-Hanna et al (2003, pp233–235) argue that the sudden shift from diets derived from hunting, fishing and gathering to those based on Western store-bought foods is an important risk factor linked with the deterioration in the mental health of circumpolar peoples. This claim is based on several lines of evidence. For example, the decline in consumption of omega-3 fatty acids has important implications for neuronal and brain development, function and health, and this has been associated with increased levels of aggression, depression, postpartum depression and suicide. Given the scientific evidence on the adverse effects of store food on the health of aboriginal peoples, it is not surprising that some indigenous groups view this so-called 'whitemans' food' as literally and symbolically polluting (Adelson, 2000, p104).

Pollution and country foods

The decline in aboriginal wild food consumption has a generational basis (Wein et al, 1991; Tracy and Kramer, 2000, p46; Pars et al, 2000; Lawn et al, 2002), and this coincides with policies of relocation and sedentarization, as well as with the acceleration of resource extraction activities from indigenous peoples' land and water resources. Not only do such activities bring with them an influx of non-native people requiring processed and frozen foods (this region is beyond the zones of agricultural production), but the industries themselves disrupt the relationships between aboriginal peoples and the lands. The decrease in country food consumption among aboriginal peoples affected by industry has been shown to be closely related to difficulties in hunting and reduced availability of animals, and to community concerns over the taste and safety of the wild foods (Loney, 1995, p233). Hence, industrialization of aboriginal lands creates both a push factor, discouraging hunting and fishing, and a pull factor, drawing people to processed foods because of fears over the adulteration of wild foods from industry (see Horton, 2004, p10A). In northern areas, processed foods have been even more attractive because of the lower costs compared with fresh produce, which is perishable, and consequently relatively expensive, especially to aboriginal families living on welfare.

The decline of country food consumption has coincided with the new threat from contaminants in country foods. For example, radioactive caesium (Tracey and Kramer, 2000, p48) and cadmium (Adelson, 2000, p84) have been found in caribou in the Canadian north. Methylmercury has been discovered in fish caught by Eastern James Bay and northern Manitoba Cree (Delormier and Kuhnlein, 1999, p182; Loney, 1995, p239), along with mercury, PCBs and pesticides in traditional foods consumed by Inuit populations in Greenland (Pars et al, 2001, p29). One of the most notorious cases of mercury poisoning affects the Ojibwa people of Grassy Narrows, northern Ontario. In the 1970s, it was discovered that a pulp mill was the source of mercury poisoning of fish caught by Ojibwa. On recent visits to the Grassy Narrows and Wabaseemong reserves, the Japanese neurologist who publicized the first cases reported that some of the residents experienced increased symptoms of the poisoning with age (Aiken, 2004). Even if the industrial developments are not as malign in their effects as this case, there are always some adverse changes to local ecosystems. Many aboriginal peoples believe that such damage diminishes the abundance of animals (Adelson, 2000, p84).

For the Innu in Labrador, environmental threats are posed by a number of large industrial projects. These include mercury in fish caught in some of the water passing through the Churchill Falls hydroelectric project, adverse changes to animal habitats (e.g. waterfowl migration patterns), water pollution from the Voisey's Bay mine, the creation of the Trans-Labrador highway, connecting Goose Bay with Labrador City, and low-level flight training (see Samson, 2003a, pp96–116). As with similar industrial projects in Canada, these also have much wider negative effects on the social fabric of the peoples themselves. The creation of hydroelectric generating projects has been found to be associated with interpersonal violence, family break-ups, alcohol and drug abuse and cultural disintegration among aboriginal peoples across Canada (Loney, 1995; Kirkness, 2000, p309).

The Physical Activity Transition

Activity transition in settled and agricultural societies

The second transition of significance to Innu physical and mental health is the activity transition. Like the nutrient transition, this has already occurred in industrialized countries, and is having a significant impact on health and well-being (CDC, 1996; Wanless, 2002; Lang and Heasman, 2004; Pretty et al, 2005a). Along with diet, physical activity is now known to be an important determinant of health and well-being. Again, human metabolism and genetic make-up have been unable to adapt to the rate of change and magnitude of changes in lifestyle that have taken place over recent decades. People in both industrialized countries and urban settlements in developing countries have become increasingly sedentary in all aspects of daily life, including during leisure time, in travelling to and from work, and during work itself. In Europe, there has been a dramatic fall in physical activity over the past 50 years with on average 2MJ less energy output per day in adults aged

20–60 years (Eurodiet, 2001). Yet the public health consequences of these changes have not, until very recently, been widely discussed or accepted (DCMS, 2002; DoH, 2004). The Eurodiet (2001) study states 'the importance of physical activity has been underestimated for many years by both doctors and policy-makers'. In the US, the report of the Surgeon General (CDC, 1996) documented similar alarming declines in physical activity and consequent increases in ill health, finding that 60 per cent of Americans are not regularly active, and 25 per cent are not active at all.

Although there is no systematic data to establish long-term trends, it is clear that lifestyles have changed in many countries, and that even leisure time is increasingly filled with sedentary behaviour (CDC, 1996). Echoing Popkin's phrase (1998), we believe that modern societies have also gone through an 'activity transition' in the past two to three generations (Pretty et al, 2004, 2005a, 2005b), with people no longer active in the workplace nor in travelling to and from work, nor during leisure time. This too has very significant health consequences for whole populations.

Yet physical activity is known to reduce the risk of dying from coronary heart disease, the leading cause of death in industrialized countries, and also reduces the risk of developing diabetes, hypertension and colon cancer. It enhances mental health, fosters healthy muscles and bones, and helps maintain health and independence in older adults (Paffenbarger et al, 1994; CDC, 1996; Hermansen et al, 2002). Compared with active people, those who are sedentary have a 1.2–2 fold increased risk of dying (Paffenbarger et al, 1994), with levels of cardiovascular fitness strongly associated with overall mortality (Berlin and Colditz, 1990). Physical activity provides a protective effect in later life, though taking up physical activity at any time can have an immediate effect on long-term morbidity (Paffenbarger et al, 1994).

A variety of studies have also shown that aerobic exercise improves self-esteem as well as having an antidepressant effect (Fox and Corbin, 1989; North et al, 1990; McDonald and Hodgdon, 1991; Scully et al, 1999; Frumkin, 2001; Pretty et al, 2005a). Exercise appears to affect an undetermined psycho-physiological mechanism, leading to improved fitness and/or weight loss, more autonomy and personal control, and a better sense of belonging and significance. However, there is much about the underlying mechanisms that is not known (Camacho et al, 1991; Farmer et al, 1998). It appears that if the amount of activity decreases in active individuals, then the risk of depression increases (North et al, 1990; McDonald and Hodgdon, 1991; Dishman, 1995). Paffenbarger et al (1994) found that men who engaged in three hours or more of sporting activity had a 27 per cent reduction in the risk of developing depression at follow-up compared to those who did an hour or less. There was also some important evidence for a dose response. Those who expended 10.5MJ or more per week were 28 per cent less at risk of developing clinically recognizable depression than those expending less than a 4MJ wk^{-1}; those who expended 4–10MJ wk^{-1} had a 17 per cent risk reduction compared to those in the least active group.

Physical activity in the country

The importance of sedentarization as a factor in reducing physical activity has been documented elsewhere in Canada amongst Cree communities, where efforts to increase physical activity have centred on aerobic classes, walking and cycling, and swimming (Lavalée et al, 1994), even though 19 per cent of those questioned said they preferred traditional activities such as wood-cutting or snowshoeing. Medical professionals working with the Innu have also recommended organized physical activities, but there has been little take-up as a result of ongoing social problems in the villages and the foreign nature of such activities which separate exercise from purposeful physical activity.

By contrast, physical activity in the context of hunting is an integral part of a way of life. Innu almost unanimously speak of hunting as fulfilling and therapeutic, providing a stark contrast to the inactive and stressful life in the villages. Observing the changes brought about when Innu leave the villages and spend months in the country, Andrew and Sarsfield (1984, p429) remark, 'alcohol abuse suddenly stops. A combination of improved diet, a rigorous lifestyle and the stable emotional and social environment offered by a functioning Innu society, make for a startling contrast with life in the villages.' In his seminal study of northern Athapaskan people, Brody (1981, p253) describes similar transformations in which 'tense people relax; the uncertain and shy become more confident', and all members of the hunting camp find the physical activity satisfying.

The activity transition for the Innu has been more rapid and pronounced than it has been for people in industrialized countries. Their transition has been from a nomadic lifestyle centred on physically demanding hunting, gathering and fishing to a modern lifestyle with its associated motorized vehicles and inactive jobs. As late as the end of the 1960s, the entire Mushuau Innu population was using dog teams, walking in winter on snowshoes and transporting themselves across long distances in blizzards, often under sub-zero temperatures with no guarantees of a successful hunt.

The anthropologist Henriksen (1973, pp21–24) recounts Innu endurance and stamina that indicates just how much physical activity could be involved in Innu life. The camp in which he was staying in the 1960s was situated 100 miles inland from Davis Inlet. There a group of men decided to go to the trading post to purchase some provisions. They rose at one in the morning and set off on sleds, taking turns to ride and run beside the sled. Some of the men shot ptarmigan along the way. They travelled non-stop until noon, having only a 15-minute tea break, before travelling further until five o'clock when it became dark. They then had to find a suitable campsite near a creek. The tent frame and supports were then fashioned from surrounding trees and the canvas tent thrown over the frame. A floor was built by shovelling away snow and then tramping down the remaining snow. The dog's meat was boiled and the dogs tied up before the men were able to prepare their own food for the night. After eating, the men got up and tramped down a path in the snow to make their passage easier the next day. They returned to the camp at one o'clock in the morning, having been up for 24 hours, then rose after two hours sleep and finally arrived at Davis Inlet by the next afternoon. After spending a short night at Davis Inlet, the group set off back for their camp 100 miles distant, and returned in the same fashion as the outward journey. Even today, with snowmobiles and outboard motors, the Innu hunting life is highly physically demanding for all members of the camp, from the older *Tshenut* to the children.

Energy expenditure

There are no time and motion studies to illustrate the precise difference in physical activities in the country compared with life in the village. However, both written records and the testimony of Innu indicate a large difference in energy expenditure. Table 4.4 summarizes the hourly calorific output for a selection of activities typical to both country and village life. In the country, most days involve long periods of physical activity. First, Innu have to get to where they will camp. In the past, this would have been by walking, with loads carried or dragged on sledges. Today, most use snowmobiles in winter. From the camp, men engage in hunting and trapping, and fuelwood cutting and hauling. Often they will be away for the whole day. Women engage in gathering plants and boughs of spruce for tent floors, snaring rabbits, setting nets for fishing, and a wide range of camp activities, including preparing and cooking foods, collecting water, looking after infants, repairing cloths and tents, and taking care of meat and hides. Jean-Pierre Ashini, interviewed in 2004, told us that, 'we were always busy in the country. I didn't consider this

Table 4.4 *Energy expenditure in various country and village activities (for adult of 77kg, 170lb)*

Activity	*Energy expenditure (MJ hour^{-1})*
Sitting or lying (watching TV)	0.42
Writing	0.54
Cooking	0.88
Shopping	1.21
Walking in country	1.59
Walking at 6.4kph (4mph)	1.88
Running across country	3.16
Fishing	1.21
Canoeing	1.42
Snowmobiling	1.46
Snowshoeing	3.26
Woodcutting with axe	3.76
Hand sawing	2.36
Stacking firewood	1.71
Playing ice hockey	4.01

Note: Energy expenditure rises with body weight (e.g. a 47kg (104lb) person snowshoeing expends 2MJ hr^{-1}, whereas a 98kg (216lb) person expends 4.1MJ hr^{-1}.
Source: McArdle et al, 1996

hard work'. Only when there were heavy snow storms or days of continuous rainfall did activity diminish in Jean-Pierre's camps (see also, Ambler, 1996; Pratt, 2002).

Hunting days would typically begin at daybreak so that Innu could maximize the hours of daylight while hunting. This could mean 12–15 hours of walking a day, which during the spring and summer would require 19–25MJ of energy expenditure, and up to 38–48MJ in winter. Another typical day might involve 6 hours of cutting trees and hauling wood for fuel – with an expenditure of 17.5MJ. Innu today recognize what such activity does to them physically. Jean-Pierre Ashini says, 'I eat a lot in the country, but I burn it off. Even though I am eating fatty foods, I am still 20–30 lbs lighter than when I live in the village'.

Some Innu recall acts of extraordinary physical endurance and capacity. Jean-Pierre Ashini recalls carrying a whole caribou of some 160kg weight some 2.5km back to camp. Dominic Pokue, interviewed in 2003, remembers as a young man canoeing 65km in two days, and travelling 110km in five days to reach camp at Minaipi Lake. Sometimes travel to the camp could involve walking both day and night, often carrying or dragging heavy loads. When men were hunting, they could travel very long distances, often spending 1–2 days away from the camp until they were successful in the hunt. Mary May Rich (interviewed in 2003) says women were active all day until they went to bed – chopping wood, collecting boughs, preparing foods. She did not consider this hard work, but an integral part of life and her identity. She said, 'I miss life in the country. It hurts to be in the village now.'

It is clear that physical activity in the country involves energy expenditure in excess of the normal recognized maximum intake for adult women and men (8–10MJ day^{-1}). A typical day in the village might only involve expenditure of 0.8–2.1MJ on physical activity (not counting sitting, lying, etc.). By contrast, a typical day in the country might involve expenditure of 12.5–50MJ, depending on time of year and activities. Consumption of food calories would therefore rarely exceed energy expenditure. In the village, however, intake greatly exceeds expenditure. For those Innu without jobs, a typical day may involve no more physical activity than an hour of walking from house to house or to the local store. Some children with bicycles may be more active and new sports facilities in the villages now occupy the time of some Innu children. Despite this, without access to the country, the Innu have little or no regular physical activity to fill the vacuum created by lack of hunting, trapping and gathering. It is, therefore, inevitable that energy input from food, even around recommended maximum intakes, will exceed expenditure. As we have shown, the situation is considerably worsened by the adoption of modern diets dense in fats and calories.

Restoring Country-based Activities

This disconnection from the country has a profound effect on the Innu's identity and their sense of connection to places and to each other. Underlying the nutritional and physical activity transitions is a fundamental change from largely self-reliant nomadic lifestyles in close contact with the land to welfare-dependent settled existences in villages. The Innu are virtually unanimous in describing *nutshimit* (the country) as synonymous with health (Samson, 2003a, pp255–262). Despite the open admission of some hardships, the country is depicted as providing the physical, mental and spiritual sustenance needed to survive as well as the social solidarity needed to maintain the Innu as a distinct society. For example, in a vast amount of Innu testimony on the changes imposed upon them since sedentarization, *nutshimit* was mentioned repeatedly as a source of healing and revitalization, often making direct links between wild food, physical activity, collective autonomy, and physical and psychological strength (Innu Nation and Mushuau Innu Band Council, 1995). Reports from explorers, scientists and other non-native observers before sedentarization also depict the Innu as a healthy, vibrant and self-reliant people, living into advanced age (Turner, 1979 [1889], p106; Tanner, 1944, pp599, 663).

The idea that being in the country can bring mental health and esteem benefits should not come as a surprise, as it has been established by a variety of empirical studies on largely urban-based people in industrialized countries (Pretty, 2004). These include analyses of the effects of views from the window or in pictures (Moore, 1981; Ulrich, 1984; Tennessen and Cimprich, 1995; Kaplan, 2001; Kuo and Sullivan, 2001; Diette et al, 2003), of incidental exposure to nature (Cooper-Marcus and Barnes, 1999; Wells, 2000; Whitehouse et al, 2001; Wells and Evans, 2003), and of immersion in wild nature (Hartig et al, 1991, 2003; Fredrickson and Anderson, 1999; Williams and Harvey, 2001; Herzog et al, 2002). We must, therefore, assume that the same applies to the Innu. This is reinforced by a growing body of research in social psychology and epidemiology relating to other aboriginal communities in Canada. These studies indicate that a command of traditional knowledge, spirituality, and higher levels of cultural continuity are associated with less suicide, solvent abuse and self-destructive tendencies (Chandler and Lalonde, 1998; Dell et al, 2002). Researchers noting the close association between suicide and rapid social and cultural change in the far north have recommended both 'activities directed towards continuity of valued practices … continue to be developed' (Kral, 2003, p38) and a 'recovery of tradition' (Kirmayer et al, 2003, pS16).

Given the profound loss of autonomy and change in lifestyle brought about by sedentarization, it is doubtful that the Innu will revert to permanent nomadic hunting. But, with only very limited wage labour options and no viable educational training or economic plan for the Innu villages, it is clear that country-based activities could be vital for both economic and cultural survival of a sizeable number of Innu. Several policy options are available to increase access to the country and its food whilst not contributing to any further natural resource declines. These would not represent a 'backward' step for the Innu, but would rather seek to make the best use of available technologies and practices. Several of these options have been tested elsewhere, such as the outstation movement for Aborigine communities in Australia (Morice, 1976) and ecotourism in Saami areas of Scandinavia and among indigenous peoples in Siberia. For the Innu, these options are not necessarily new. Some have been discussed for decades, but no action has been taken. There is now even more urgency for action.

We suggest four key policy changes:

1 a regional food policy to promote country food sourcing and consumption;
2 following the recommendations of the Canadian Human Rights Commission (Backhouse and McCrae, 2002), a fully-funded outpost or hunter support programme to strengthen regular connections to the country;
3 an ecotourism programme to increase visitor travel to the country and expenditure for Innu goods and services;
4 a new school calendar policy to ensure that children can visit the country for a month or more in spring and autumn without increasing their likelihood of being held back a year for missing school time.

Establish a food policy for country food

Some countries, such as Greenland, have progressive policies to support hunting lifestyles and consumption of country foods (Marquardt and Caulfield, 1996). The Greenland Home Rule government has been promoting local country food markets since 1988, and hunters regularly sell via formal kiosks, informally to relatives and neighbours, directly to schools, hospitals and senior citizens' homes, and directly to government-controlled processing facilities. The aim of the policy is to support country food consumption as a substitute for expensive and less healthy imported foods. At the same time, such a policy helps to promote the economic viability of indigenous communities. Country foods are not permitted to be exported. An important factor which enables this in Greenland is that there is effective indigenous control over land and sea tenure systems (Marquardt and Caulfield, 1996, p116).

Experience closer to Innu country shows that as long as Innu were able to maintain collective control of certain lands and waters, as consistent with the United Nations Draft Declaration on the Rights of Indigenous Peoples, such a policy could be a possibility. In the Inuit and Cree regions of northern Quebec, a Hunter's Support programme has been in existence since 1982 when the Quebec provincial government legalized it. The programme operates by the province releasing funds to aboriginal organizations that pay Inuit and Cree hunters for the meat and fish they bring home. It also helps to subsidize the purchase of hunting equipment, transportation and a small fee for the hunters' time. After taking some of the food from the hunters, the aboriginal organizations then distribute food throughout the villages for free. The aim of the programme is to encourage the perpetuation of hunting and to offer alternatives to aboriginal hunting families that are excluded from, or do not wish to participate in, wage labour (Kishigami, 2000).

It is clear that a similar policy could assist in maintaining hunting, fishing and trapping activities as well as improve the diets of the Innu. If pursued, such a governmental investment could be perceived as a preventive health measure, avoiding healthcare costs and averting some of the suffering associated with sedentary village life. To date, the government of Newfoundland has not been as imaginative as its Quebec counterpart in implementing such a programme.

A further suggestion is a policy in Labrador to encourage local food sourcing by stores and institutions (e.g. hospitals, schools). While this policy may conflict with the religious antipathy many Innu feel to the buying and selling of animals, especially the caribou, it would be possible to source some fish and wildfowl. How to revise incentives for the private food stores is more difficult. Northern stores in Canada are smaller than their southern counterparts, with, according to one study, 457 items compared with 10–20,000, and 20–50 times less the floor space (Green and Green, 1987). Very few sell fresh meat, fish and country foods. If an accelerated programme of activities in the country were to be initiated, however, a reinvigorated communal system of food distribution could make some commercial transactions superfluous and reduce reliance on cash.

Reinstate the Outpost programme

Access to the country now requires money and technologies, especially for older Innu. With no settler communities and few industrial incursions except the Voisey's Bay mine, the Innu in Natuashish can access the immediate country relatively easily. However, further excursions to favoured hunting and fishing locations such as Kamestastin and Ashuapun require snowmobiles or airplanes. Because of settler and industrial activity in Central Labrador, the Innu living in Sheshatshiu are more heavily reliant on money and technology to reach preferred locations in the country. Unfortunately, the Outpost programme which funded Innu hunting encampments in the autumn and spring of each year has been discontinued. This is despite a recommendation from the Canadian Human Rights Commission in 1993 that this programme should be continued indefinitely as a crucial enabler of Innu cultural continuity (Backhouse and McCrae, 2002, p7).

In this regard, the government has yet to honour its own obligations towards the Innu. The follow-up report concluded that 'the Government has not implemented that aspect of the second recommendation in the 1993 Report that called on the Government of Canada to preserve "the unique aspects of existing arrangements such as the outposts program"' (Backhouse and McCrae, 2002, p3). An immediate reinstatement of funding for this important project (or one like it) is necessary if Innu health is to be restored and cultural continuity maintained. While no research has been done on the uptake that a reintroduced Outpost programme would have, there is ample anecdotal evidence that large numbers of the Innu population would avail themselves of the opportunities to experience healthier and more meaningful activities in the country and remove themselves from the many sources of suffering and pain in the villages. A Band Council commissioned study of *Tshiskutamashun*, an Innu experiential learning project in the country in 1999, found widespread support for its continued existence, with unanimous support among adults (Samson, 2000/01; Samson, 2003a, pp218–221).

Promote ecotourism

At present, the Innu are almost totally reliant on funds from the Canadian state for their village-based livelihoods. Ecotourism provides an opportunity to build a small Innu economy that would encourage more contact with the country, while also having little ecological impact on the landscape. Possible projects could include many of those now being formulated by the Tshikapisk Foundation, an organization of Innu hunting families dedicated to revitalizing Innu country life through specifically Innu educational projects and revenue-generating activities. The Foundation has secured funds for the construction of an Innu cultural centre at Kamestastin Lake. From Kamestastin and other locations, the unspoiled terrain of boreal forests, rivers and tundra affords numerous opportunities for fishing, caribou migration viewing, trekking, cross-country skiing and variants of cultural tourism in which clients would share in Innu country activities of fishing, hunting and gathering. Paying clients would also be involved in learning camp skills, Innu crafts and events would be organized so that we would hear about the history of the Innu, including Innu legends and cosmology. Ecotourism along these lines could provide valuable funding for the various Tshikapisk experiential learning projects by which Innu youth could undertake a rigorous curriculum of Innu learning and be exposed to country life for a prolonged period of time. Equally important is that ecotourism could provide employment for those Innu preferring a more country-based life, lessening their dependence on welfare and government funds (Tshikapisk Foundation, 2004).

Amend the school calendar

A relatively simple adjustment to the school calendar could be made to assist Innu families with balancing country activities and village obligations. At present, schoolchildren are in session during the most important hunting seasons, the autumn and spring, and are on vacation during the long summer months when the presence of blackflies and the migration patterns of the animals make hunting less desirable. The Innu themselves and outside researchers including Henriksen (1993, p6) for the Mushuau Innu of Davis Inlet and Samson (2000/01) on behalf of the Sheshatshiu Innu Band Council have made recommendations to the Labrador School Board to change the calendar, but no action has been taken by the authorities.

In Quebec where several school boards have been devolved to Innu control, modifications to the school calendar, enabling Innu children to participate in hunting activities for short periods during the autumn and spring have been made. Similarly, the Cree School Board serving ten Cree communities around the James Bay and northern Quebec areas is strongly committed to instruction in the Cree language and value system. School calendars primarily follow the dominant North American model of instruction from August to June, but make some allowance for country activities in May through the 'floating goose break'. Although the Labrador School Board which controls Innu schools in Sheshatshiu and Natuashish has included 'culture days' in its curriculum, these consist primarily of *Tshenut* providing instruction in Innu skills or storytelling in the school building, and therefore, out of the predominant context of the country in which these are most meaningful (Samson, 2003a, pp189–192).

In some other parts of Canada, similar arrangements have been made to incorporate native activities within schools. On the whole, however, very little has been done across North America to reconcile the conflict between the statutory schooling schedule and the seasonal rhythms of Native American cultural activities. This is because an agricultural society model has simply been imposed, reflecting the need for 'summer holidays', originally designed to allow children to help with the harvests, a need which is nonsensical in the far north. The model was also indirectly imposed as a means of eradicating indigenous practices, sensibilities and orientations to time, and inculcating a different time discipline necessary for wage labour (Pickering, 2004).

Concluding Comments

If the scale of health problems experienced by indigenous populations with longer standing experiences of assimilation and colonization is any indication, the future of the Innu looks bleak. According to a recent report by the US Commission on Civil Rights (2004), Native Americans in the US are 770 per cent more likely to die from alcoholism, 650 per cent more likely to die from tuberculosis and 420 per cent more likely to die from diabetes than the general population. If figures could be obtained for the Innu they are likely to approximate to the US rates for alcoholism and diabetes, though not for tuberculosis.

Part of the problem lies in the fact that while much money is invested in treatments for the medical, social and psychological pathologies that afflict the Innu, hardly any resources are devoted to prevention. Canadian authorities take the contemporary village as the baseline for social intervention, devoting funds almost exclusively to village-based solutions. This is lamentable for the Innu who continue to receive largely Western-based institutional treatments. This, we argue, deals only with the individual symptoms of the larger processes of cultural, spiritual and physical dispossession incurred by sedentarization. It is also costly to continue to treat what are clearly preventable conditions. The costs of the treatment of the social and health problems arising from new diets and sedentary lifestyles are likely to far exceed the costs of a restoration of country-based activities we suggest here.

But this will require a fundamental change in the way local, regional and national policy makers conceive of the problems that the Innu face. Canadian policy makers will have to be more imaginative in working with the Innu. They will have to embrace 'bottom-up' ideas such as the various programmes offered by the Tshikapisk Foundation. Of course, it is not helpful to look to the government for all the answers. The initiatives of many Innu to spend time in the country practising their way of life, eating wild foods and benefiting from the plentiful exercise of country life is vital to the success of any of the positive changes we are endorsing in this paper. These endeavours could be facilitated by a combination of some government subsidies through an Outpost or Hunter Support programme and the development of non-profit revenue generation through ecotourism and other activities consonant with Innu hunting life.

It is clear, too, that the changes suggested here also have some relevance for people elsewhere in industrialized countries who are suffering ill-health from inappropriate diets and sedentary lifestyles. Better connections to food and the land, supported by reformed agricultural, food and land policies, could do much to promote wider and long-lasting changes in behaviour (Pretty, 2002; Pretty et al, 2004). However, the trends seen through most food systems towards commodification and processing of foods, combined with the self-interest of manufacturers and retailers, will make these changes difficult to sustain unless individuals and communities are able to take the links between health, food and the natural environment seriously, and act to develop new projects to address them. Being in the country for the Innu has considerable resonance for people in other societies who too have become disconnected from nature, land and food, yet who have a greater political voice to do something about these disconnections.

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5

Language: A Resource for Nature

Luisa Maffi

The concept of biocultural diversity is becoming increasingly familiar in environmental conservation circles internationally, especially since finding its way into international instruments such as the Convention on Biological Diversity (CBD) after the 1992 Rio Summit (UN Conference on Environment and Development). Article 8(j) of the CBD is specifically concerned with indigenous peoples, traditional knowledge and related rights. It states that each Contracting Party must:

> Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices.

Indigenous organizations have been very active vis-à-vis the implementation of Article 8(j) at the meetings of the Conference of the Parties (COP) to the CBD. At the latest meeting (COP IV, 4–15 May 1998, Bratislava, Slovakia), they succeeded in passing a decision that calls for the creation of a continuous working group in charge of advising on the measures necessary to protect indigenous peoples' knowledge, innovations and practices. In spite of persisting concerns about being actually enabled to participate in the working group and affect its recommendations, indigenous organizations consider this decision a success on the road to full recognition of the importance of their environmental knowledge and practices for the conservation and sustainable use of biological diversity.

While the processes surrounding the CBD have been in the spotlight, it is perhaps less well known that the first international document to incorporate an integrated notion of biocultural diversity was the Declaration of Belém of the International Society of Ethnobiology, elaborated in 1988 at the First International Congress of Ethnobiology in Belém, Brazil. Aware of the simultaneous

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extinction threats facing tropical and other fragile ecosystems on the one hand, and indigenous peoples on the other, ethnobiologists stressed indigenous peoples' stewardship over the world's biological resources and affirmed the existence of an 'inextricable link' between cultural and biological diversity on Earth.

Interestingly, at about the same time, linguists were beginning to voice widespread concern on the status of the world's languages and to warn of another impending extinction crisis, of a magnitude and pace comparable to, if not greater than, that affecting biodiversity: one that would dramatically reduce linguistic diversity through the disappearance of most of the numerically small languages spoken by indigenous and minority peoples. In linguists' calls to action vis-à-vis this crisis, a parallel was often drawn with the loss of biodiversity, as a way of suggesting comparable damage to humanity's heritage. However, in these initial pronouncements, no significant attempt was made to go beyond such parallels and ask whether there might be more than a metaphorical relationship between these phenomena. It is only recently that this question has been explicitly asked and the idea proposed that, along with cultural diversity, *linguistic* diversity should also be seen as inextricably linked to biodiversity.[1] The present article[2] seeks to contribute to the debate on these issues and linkages.

Linguistic Diversify and Biodiversity

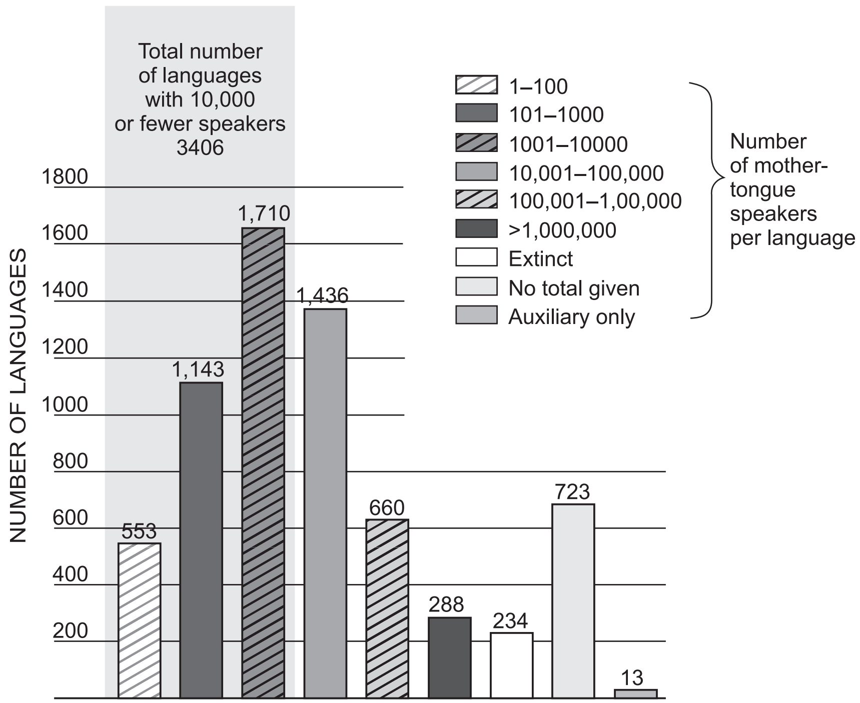
Defining and measuring linguistic diversity

In order to address this issue, let us begin by defining linguistic diversity. As with biodiversity, there are various definitions of linguistic diversity. Most commonly, however, the number of different languages spoken on Earth is used as a proxy for global linguistic diversity. There are an estimated 5000 to 7000 languages spoken today on the five continents, of which 32 per cent in Asia, 30 per cent in Africa, 19 per cent in the Pacific, 15 per cent in the Americas, and 3 per cent in Europe. Of these languages, about half are spoken by communities of 10,000 speakers or less; half of these, in turn, are spoken by communities of 1000 or fewer speakers (Figures 5.1–5.2). Overall, languages with up to 10,000 speakers total about 8 million people, less than 0.2 per cent of an estimated world population of 5.3 billion.[3]

On the other hand, of the remaining half of the world's languages, a small group of less than 300 (such as Chinese, English, Spanish, Arabic, Hindi and so forth) are spoken by communities of 1 million speakers or more, accounting for a total of over 5 billion speakers, or close to 95 per cent of the world's population (Figure 5.3). The top ten of these alone actually comprise almost half of this global population.

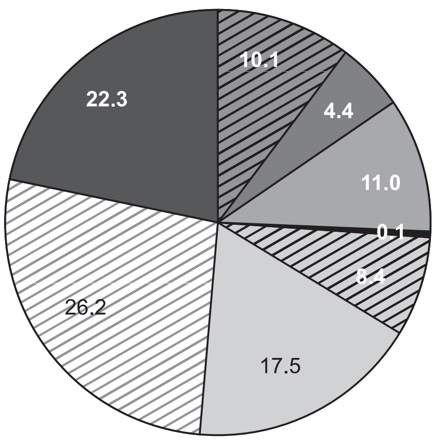
Indigenous and minority languages at risk

Taken together, these figures show that, while more than nine out of ten people in the world are native speakers of one, or other, of only about 300 languages, most



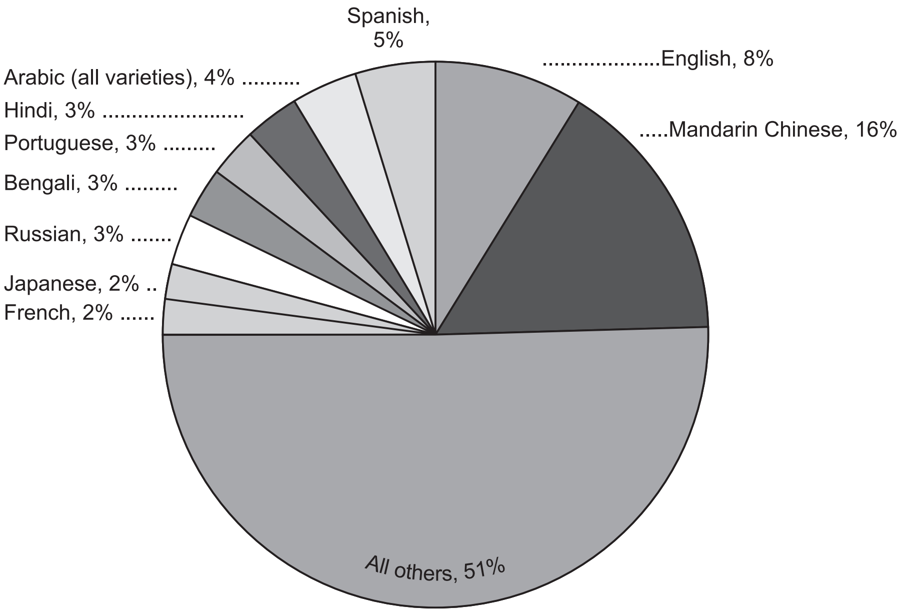
Source: From Harmon (1995)[3]

Figure 5.1 *Size classification of world's languages by number of mother-tongue speakers*



Source: From Harmon (1995)[3]

Figure 5.2 *Proportion of world's living languages by size category (n = 6526)*



Source: From Harmon (1995)[3]

Figure 5.3 *Languages with the most mother-tongue speakers: proportion of world population*

of the world's linguistic diversity is carried by very small communities of indigenous and minority people. These are the languages that have been and continue to be under threat, due to the ever-growing assimilation pressures that promote incorporation of their speakers into 'mainstream' society and the collective abandonment of the native languages in favour of majority languages (a phenomenon known as 'language shift'). Virtually all languages with 1000 speakers or less are threatened in this sense, although even more widely spoken languages are fully susceptible to the same pressures. Many of these smaller languages are already at risk of disappearing due to a drastic reduction in the number of their speakers, with younger generations decreasingly or no longer learning their language of heritage. Many more have reached a stage of near extinction, with only a few elderly speakers left. Statistics on 'nearly extinct' languages range between 6 and 11 per cent of the currently spoken languages. In some projections, as many as 90 per cent of the world's languages may disappear during the course of the next century. These figures portray a threat to linguistic diversity that may be far greater and more imminent than the threat facing biodiversity.

It is a historical fact that languages, like biological species, have undergone extinction before. Informed guesses suggest that the peak of linguistic diversity on Earth may have occurred at the beginning of the Neolithic (10,000 years Before Present), at which time more than twice the current number of languages may have been spoken. Population movements and political and economic expansion have long contributed to reducing linguistic diversity everywhere in the world, even well before the era of colonization and empire building. As with biodiversity, however, what is unprecedented is an extinction crisis of the present magnitude and pace. It has been estimated that there may already be 15 per cent fewer languages now than 500 years ago, when the era of European colonization began.[4] Losses have been especially marked in the Americas and Australia. And the trend is now accelerating throughout the world, with Australia and the Americas (especially the US) still in the lead.

Causes of language loss

By and large, the main waves of colonial and imperial expansion in human history (both European and of other major civilizations) have come not only to the detriment of local peoples' sovereignty and control over their ancestral territories, resources and cultural traditions, but also to the detriment of their ancestral languages. Whenever assimilation into the dominant culture has been the goal (as it has been in most cases), this assimilation has been effected crucially by way of *linguistic* assimilation, through the imposition of the dominant language in schooling, the media, government affairs and most other public contexts – and, in parallel, through the denigration of the local languages (and the cultures they embody) as defective, primitive, unfit for the 'modern world', as well as through the severe restriction of their contexts of use and even the explicit prohibition of and punishment for their use. Awareness of the political implications of linguistic assimilation was perhaps never better expressed than by the 15th-century Spanish grammarian Antonio de Nebrija. In 1492, presenting Queen Isabella of Spain with his grammar of Spanish (the first grammar of any modern European language), Nebrija so explained its purposes in his introduction: 'Language has always been the consort of empire'.[5]

The 'curse of Babel' debunked

We may well feel sorry for the speakers of these smaller languages who have lost or are losing their ancestral tongues. But is it not the case that this linguistic assimilation is ultimately just an inevitable consequence of the in turn inevitable process of globalization the world is witnessing? Is this not, after all, a small price to pay for intercommunication and world stability? At long last, a widespread attitude has it, humanity will be freed of the burden laid upon it by the 'curse of Babel': the multiplicity of languages. With fewer different languages in use, this line of reasoning goes, it will be easier to communicate with people elsewhere in the world; once marginalized populations will be able to develop and prosper: ethnic conflict will decrease; national unity will no longer be threatened; and we will finally be moving toward the globalized cosmopolitan world that is the ultimate destiny of humanity.

However – whatever we may think about the inevitability of globalization and the ultimate destiny of humanity – none of these arguments is supportable. First, they are mostly expounded by speakers of languages that are comfortably not at risk of going extinct. Second, and very importantly, the learning of other languages does not have to occur at the cost of losing one's own language (in technical terms, it does not have to be subtractive); it can be additive, leading to a situation of stable multilingualism in one's mother tongue and one or more other languages. Again, it is rare for indigenous or minority groups to abandon their languages in favour of a majority one without direct or indirect pressures from governments and other outside forces. Faced with the challenges of modernity, indigenous and minority language speakers may or may not wish to preserve their own languages and cultural traditions, but should not have to find themselves systematically pressured into the latter choice. Indeed, one may seriously question whether choice under such pressure can be called choice at all.

Furthermore, marginalized ethnic groups who opt for or are forced into assimilation into a linguistic and cultural majority often do not succeed in overcoming their marginalization but end up among the dispossessed within 'mainstream' society. As for the issue of ethnic conflict and national security, specialized studies show that ethnic differences (whether identified with language, culture, religion, or any aspects of social organization) do not normally constitute the source of conflict, although they may be seized upon and attributed special meaning as a basis for mobilization when conflict arises. In particular, there is no evidence to suggest that the use of different languages by neighbouring populations may constitute *per se* a cause of conflict; nor, for that matter, does monolingualism within or between countries seem to be a guarantee for peace. When populations of speakers of different languages coexisting in adjacent or the same territory do come into conflict, the causes of such conflict reside more commonly in socioeconomic and political inequality and competition over land and resources, as well as in the denial (rather than the granting) of linguistic and cultural rights.[6]

The idea of Babel as a 'curse' is a widespread interpretation of this element of the Judaeo-Christian religious tradition, yet not necessarily a valid one. It is perhaps more accurate to see the divine intervention that brings about a multiplicity of languages as a way of curbing the arrogance and single-mindedness of monolingual empire builders. Other religious traditions suggest that a diversity of languages (and cultures) is a good thing. To cite just one example, according to the Acoma Pueblo Indians of New Mexico, the mother goddess latiku causes people to speak different languages so that it will not be as easy for them to quarrel.

Multilingualism and linguistic ecologies

Above all, these arguments completely ignore that – for most of human history, and even today in many parts of the world – high concentrations of different languages have coexisted side by side in the same areas. Over 800 different languages are still spoken in the island of New Guinea – the main hotspot of linguistic diversity. There and elsewhere, complex networks of multilingualism in several local languages and pidgins or lingua francas have been a commonplace way of dealing with cross-language communication in situations of contact. This extensive multilingualism has been a key factor in the maintenance of linguistic diversity historically, countering the increasing effects of linguistic assimilation.

Linguists are only beginning to realize that there may be structure to such linguistic diversity. The functional relationships that develop in space and time among linguistic communities that communicate across language barriers have been referred to as 'linguistic ecologies'. An ecological theory of language takes as its focus the diversity of languages *per se*, and investigates the functions of such diversity in the history of humanity. It seeks to identify the mechanisms that sustain a language ecology over time – which are, in fact, the very same mechanisms that will be required to build a genuine multilingual and multicultural society in today's global world. Furthermore, the study of traditional linguistic ecologies reveals that they encompass not only the linguistic and social environment, but also the physical environment, within a worldview in which physical reality and the description of that reality are not seen as separate phenomena, but instead as interrelated parts of a whole.[7]

Language and the Environment: the Inextricable Link

Overlap of linguistic and biological diversity

To understand how language and the environment may be seen as parts of the same whole, let us first consider some striking correlations between linguistic and biological diversity.[8] The majority of the smaller languages (which, as we have seen, account for most of the world's linguistic diversity) can be labelled as 'endemic', in that they are spoken exclusively within this or that country's borders. Comparing a list of countries by number of endemic languages with the IUCN list of 'megadiversity' countries, one finds that 10 out of the top 12 megadiversity countries (or 83 per cent) also figure among the top 25 countries for endemic languages (Table 5.1).

A global cross-mapping of endemic languages and higher vertebrate species brings out the remarkable overlap between linguistic and biological diversity throughout the world. Similar results can be obtained by cross-mapping endemic languages and flowering plant species.

Language, knowledge and human–environment coevolution

What may account for these correlations? Several geographical and environmental factors have been suggested that may comparably affect both biological and linguistic diversity, and especially endemism: (1) Extensive land masses with a variety of terrains, climates and ecosystems (e.g. Brazil, China, India, Mexico, US); (2) Island territories, especially with internal geophysical barriers (such as Australia,

Table 5.1 *Megadiversity countries: concurrence with endemic languages*

- **Australia** (5)
- **Brazil** (8)
- **China** (17)
- **Colombia** (23)
- **Democratic Republic of the Congo** (9)
- Ecuador (–)
- **India** (4)
- **Indonesia** (2)
- Madagascar (–)
- **Malaysia** (15)
- **Mexico** (6)
- **Peru** (18)

Concurrence: 10 of 12 (83%)

Countries in top 25 for endemic languages in bold*. Country listed alphabetically (endemic language rank in parentheses).

Source: *Modified from Harmon (in press). 'Megadiversity countries' have been identified as those likely to contain a large percentage of global species richness. The 12 listed were identified on the basis of species lists for vertebrates, swallowtail butterflies and higher plants

Indonesia, New Guinea, the Philippines); (3) Tropical climates, fostering higher numbers and densities of species (e.g. Cameroon, Democratic Republic of the Congo). All these factors are thought to increase linguistic diversity by increasing mutual isolation between human populations and thus favouring linguistic diversification.

In addition, an ecological phenomenon has also been proposed as possibly accounting for biodiversity-linguistic diversity correlations: a process of coevolution of small-scale human groups with their local ecosystems, in which over time humans interacted closely with the environment, modifying it as they adapted to it, and acquiring intimate knowledge of it. This knowledge was encoded and transmitted through the local languages, which thus became in turn moulded by and specifically adapted to their socio-ecological environments. As one linguist puts it: 'Life in a particular human environment is dependent on people's ability to talk about it.'[9]

This may sound like a truism worthy of little note, but it is not so. That remark embodies one of the most basic functions that language performs for humans, and in its deceptive simplicity reveals where the 'inextricable link' between language and the environment is to be found. At the local level, linguistic and cultural distinctiveness has often developed even among human groups defined as belonging to the same cultural area or whose languages are considered to be historically related, and who live within the same bioregion. As local groups have adapted to life in specific ecological niches, they have developed specialized knowledge of them, and specialized ways of talking about them, to convey this vital knowledge and ways of acting upon it for individual and group survival. What has been said of Australian Aboriginal tribes could be said in hundreds of other cases of local peoples around the world: 'Coincidences of tribal boundaries to local ecology are not uncommon and imply that a given group of people may achieve stability by becoming the most efficient users of a given area and understanding its potentialities.'[10]

Linguistically anthropogenic landscapes

In this light, then, it becomes possible to suggest that landscapes are anthropogenic (human-made) not only in the sense that they are physically modified by human intervention – as ethnobiologists and ethnoecologists have shown contra the myth of pristine wildernesses – but also because they are symbolically brought into the sphere of human communication by language: by the words, expressions, stories, legends, songs that encode and convey human relationships with the environment and that inscribe the history of those relationships onto the land.

Traditional place-naming also both occurs in an ecological context and carries high cultural significance for indigenous peoples, 'as a framework for cultural transmission and moral instruction, as a symbolic link to their land, and as a ground for their identity'. Named landmarks convey and evoke knowledge on both the physical environment and daily human activities, historical events, social relations, ritual and moral conduct: 'wisdom sits in places'.[11] Landscapes are networks of such places of knowledge and wisdom and thus, in this sense also, anthropogenic.

Losing the Link

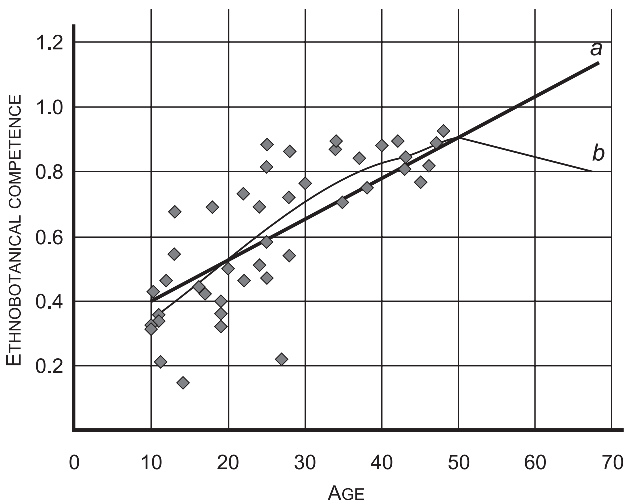
The extinction of experience

It is this inextricable link between language and the environment that is lost when external forces begin to undermine traditional cultures, pushing them into the 'mainstream'. Whether this process is propelled by dispossessing local peoples of their sovereignty over land and resources, trampling their cultural traditions, or promoting linguistic assimilation (generally, all three phenomena occur at once and are mutually reinforcing), the end result is the same. Local peoples lose control over, and contact with, their natural and cultural environments. As they are removed from their lands, or subsist in highly degraded ecosystems, and are absorbed into a market economy in which there normally is little room for traditional subsistence practices and resource use, local ecological knowledge and beliefs find the wisdom about human–environment relationships begin to lose their relevance to people's lives.

This phenomenon has been called the 'extinction of experience', the radical loss of direct contact and hands-on interaction with the surrounding environment.[12] In turn, local languages lose their crucial function of communicating and upholding such knowledge, beliefs and wisdom that are increasingly less significant and intelligible to younger generations. Furthermore, local knowledge does not 'translate' easily into the majority language to which minority language speakers switch; and along with the dominant language usually comes a dominant cultural framework that begins to take over and displace the traditional one. Because in most cases indigenous knowledge is only carried by oral tradition, when shift toward 'modernization' and dominant languages occurs and oral tradition in the native languages is not kept up, local knowledge is lost. Due to its place-specific and subsistence-related nature, local ecological knowledge is at an especially high risk of disappearing.

Knowledge loss

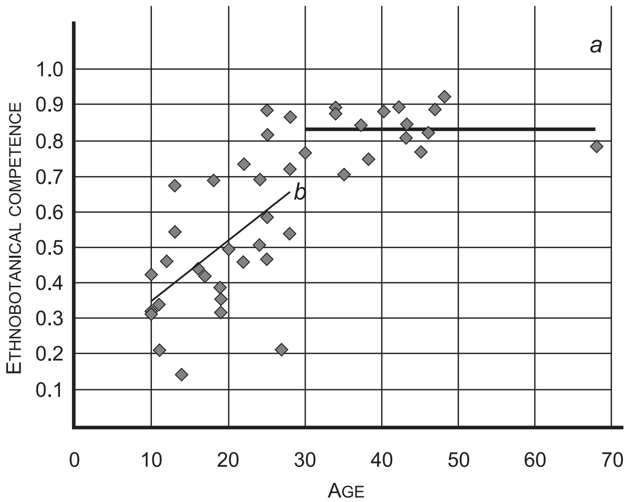
The patterns and factors of erosion of languages and linguistically encoded environmental knowledge are beginning to be systematically identified and quantified. For example, among the Piaroa Indians of Venezuela, the persistence of ethnobotanical knowledge has been found to negatively correlate with age, bilingualism and schooling (Figures 5.4–5.7).[13] Younger, more acculturated Piaroa show dramatically lower levels of competence than their older, less acculturated counterparts in identifying local plants by their Piaroa names and the cultural uses of those same plant species.



The regression lines drawn represent: (a) a linear or binomal model ($r^2 = 0.539$; $y = 0.2739 + 0.0126x$); and (b) a curvilinear or polynomial model ($r^2 = 0.625$; $y = 8.3118 + 0.4465x - 3.359\sqrt{x} - 15.7723x^2 - 0.0023x^3$).

Source: Zent (in press)[13]

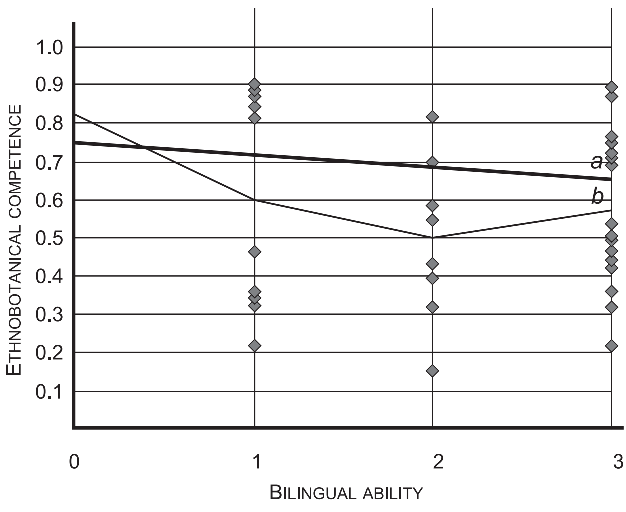
Figure 5.4 *Regression of age and ethnobotanical competence among the Piaroa of Venezuela*



The regression lines drawn here represent: (a) a linear model for 30 and above age group ($r^2 = 0.002$; $y = 0.8176 + 0.00032x$); and (b) a linear model for below 30 age group ($r^2 = 0.296$; $y = 0.1786 + 0.017x$).

Source: Zent (in press)[13]

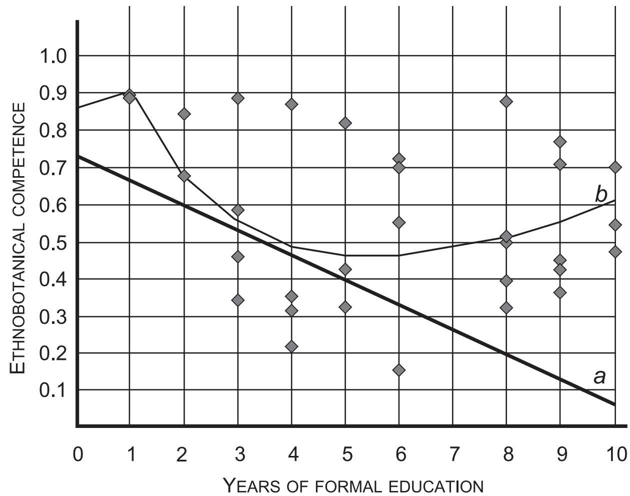
Figure 5.5 *Regression of age and ethnobotanical competence according to age subgroups among the Piaroa of Venezuela*



The regression lines drawn here represent: (a) a linear or binomial model ($r^2 = 0.113$; $y = 0.727 - 0.0667x$); and (b) a curvilinear or polynomial model ($r^2 = 0.209$; $y = 0.8154 - 0.226x + 0.0162x^3$).

Source: Zent (in press)[13]

Figure 5.6 *Regression of bilingual ability and ethnobotanical competence among the Piaroa of Venezuela*



The regression lines drawn here represent: (a) a linear or binomial model ($r^2 = 0.22$: $y = 0.7471 - 0.0307x$); and (b) a curvilinear or polynomial model ($r^2 = 0.415$; $y = 1.7739 + 0.2311x - 1.1022\sqrt{x} - 0.0009/x$).

Source: Zent (in press)[13]

Figure 5.7 *Regression of formal education and ethnobotanical competence among the Piaroa of Venezuela*

Often, the loss of traditional languages and cultures may be hastened by environmental degradation – such as logging, mining, agribusiness, cattle-raising and so forth – by creating a negative feedback loop. In the Yoeme pueblo of the Yaqui people of the Sonoran Desert in Arizona, the performance of Yoeme ritual is hampered by the disappearance from the local environment of many plant species that were traditionally employed in religious ceremonies. Ritual is one of the main contexts for the teaching of the Yoeme Truth, and in particular of the intimate spiritual and physical connection with and respect for nature. 'Yaquis have always believed that a close communication exists among *all* the inhabitants of the Sonoran desert world in which they live: plants, animals, birds, fishes, even rocks and springs. All of these come together as a part of one living community which Yaquis call the *huya ania*, the wilderness world … Yaquis regard song [as a part of ritual] as a special language of this community, a kind of "lingua franca of the intelligent universe".' The Yoeme elders' inability to correctly perform ritual due to environmental degradation thus contributes to precipitating language and knowledge loss, and creates a vicious circle that in turn affects the local ecosystem.[13]

Preserving and Restoring Language, Culture, and Land

Community efforts

The Yoeme example clearly shows how, for local peoples, the struggle for maintaining or restoring the integrity of their cultures, languages and environments configures itself as one interrelated goal. This holistic approach is increasingly evident in the grassroots efforts that are being made around the world. As an example, Native Californians are engaging in integrated biocultural conservation efforts. The linguistic and cultural revival activities in which they are involved go hand in hand with advocacy for environmental restoration on their lands and the renewed use of native plants for traditional handicrafts, such as basket-weaving, and for other purposes.

On the other hand, if acculturation has such measurably negative effects on traditional knowledge and languages, as in the case of the Piaroa, should local peoples reject the framework of modernity altogether, including the Western schooling that brings about dominant languages and cultural patterns – or, for that matter, the biomedical care that undermines the prestige of traditional medicine, and other similar cultural change? Some indigenous groups, such as certain Amazonian tribes, have made this choice, taking refuge deeper into the forest. Others have chosen to integrate aspects of the two worlds, for instance by combining formal schooling with curricula based on their own cultural traditions and formulated in their native languages. The Hawaiians and Maori have been at the forefront of the latter kind of approach. In still other cases, educational efforts have been aimed at marking the distinction between formal Western-type learning and traditional informal learning. In Australia, several Aboriginal groups use an approach whereby they separate 'white knowledge' (literacy, numeracy, etc.), taught by monolingual English-speakers, with White-Australian content and structure, from their own Aboriginal knowledge. Their own knowledge is 'lived' rather than taught in schools.[14]

The need for choices

Whatever choices local peoples may make – and as we have seen, they make a variety of them – what matters is that there *be* choices. As in the case of language learning (acquisition of a majority language does not have to be subtractive; it can and should be additive), it does not have to be a matter of either–or between different cultural frameworks (as it is far too often purported to be by dominant cultures). Local peoples must simply remain free to consciously choose if and how much of either framework – the traditional and the exogenous – they may wish to maintain or adopt. Some groups, as in the Amazonian case, may indeed choose isolation. But others, perhaps most, will probably choose some form of integration between, or parallel adoption of, frameworks. And in so doing, after all, they will not be doing anything different – if done in freedom and not under pressure –

from what humans throughout history have done in situations of contact: mixing and matching, which has contributed to so much of the cultural and linguistic diversity that we know today.

Language as a Resource

Linguistic diversity and the human potential

So far, questions about the consequences of loss of linguistic and cultural diversity have been raised mostly in terms of ethics and social justice, and of maintaining the human heritage from the past – and rightly so. However, when we consider the interrelationships between linguistic, cultural and biological diversity, we may begin to ask these questions also as questions about the future – as related to the continued viability of humanity on Earth. We may ask whether linguistic and cultural diversity and diversification may not share substantive characteristics with biological diversity and diversification, characteristics that are ultimately those of all life on Earth.

The relevant issues relate to the adaptive nature of variation in humans (as well as other species), and to the role of language and culture as providers of diversity in humans. Human culture is a powerful adaptation tool, and language at one and the same time enables and conveys much cultural behaviour. While not all knowledge, beliefs and values may be linguistically encoded, language represents the main instrument for humans to elaborate, maintain, develop and transmit such ideas. 'Linguistic diversity … is at least the correlate of (though not the cause of) diversity of adaptational ideas.' Therefore, it is possible to suggest that 'any reduction of language diversity diminishes the adaptational strength of our species because it lowers the pool of knowledge from which we can draw'.[15]

It is true that diversity characterizes languages (and cultures) not just with respect to one another, but also internally, with patterns of variation by geographical location, age grade, gender, social status and a host of other variables. This internal variation combines with the variation ensuing from historical contact among human populations propelling language and culture change and all manner of innovation. However, as more and more languages and cultural traditions are overwhelmed by more dominant ones and increasing homogenization ensues, one of the two main motors of change and innovation – the observation of linguistic and cultural difference – breaks down, or is seriously damaged. The end result is a global loss of diversity.

Avoiding 'cultural blind spots'

From this perspective, issues of linguistic and cultural diversity preservation may then be formulated in the same terms that have been proposed for biodiversity conservation: as a matter of 'keeping options alive' and of presenting 'monocultures of the mind'.[16] It has been argued that convergence toward majority cultural models increases the likelihood that more and more people will encounter the same 'cultural blind spots' – undetected instances in which the prevailing cultural model fails to provide adequate solutions to societal problems. Instead, '[i]t is by pooling the resources of many understandings that more reliable knowledge can arise'; and 'access to these perspectives is best gained through a diversity of languages'. Or simply stated: 'Ecology shows that a variety of forms is a prerequisite for biological survival. Monocultures are vulnerable and easily destroyed. Plurality in human ecology functions in the same way.'[17]

Supporting Linguistic, Cultural and Biological Diversity: the Role of Scientists

Benefit for the many or for the few?

Pronouncements on the importance of diversity often conclude on some universalistic note. Yet it is time to go beyond these general (and generic) statements, true as they may be. That we need diversity – cultural, linguistic, biological – for the benefit of humanity is undoubtedly true. But far too often, as local peoples are the first to know, the hailed 'benefit for humanity' has actually meant the benefit (and specifically the economic benefit) of a very small, privileged subset of said humanity, one that does not include that vast majority of humans in which most of this diversity resides. Ethnoscientists have realized to their dismay that they may have been even too successful in affirming the validity of traditional ethnobiological and ethnomedical knowledge – thus unwittingly attracting droves of unscrupulous bioprospectors ('biopirates') to the lands of the indigenous peoples whose knowledge they have painstakingly documented. Supporters of cultural diversity baulk at the thought that someone may now be earning large sums of money selling multicultural T-shirts in the places where cultural diversity least abounds. And if we are good enough at explicating and advocating for the role of language in the diversity equation, the time may not be far away when someone will begin to devise ways to make a business out of linguistic diversity – and not to the advantage of those who hold most of it.

Terralingua

As we work for the maintenance of cultural, linguistic and biological diversity, we must be constantly aware of these risks. And this is why research, applied work, and advocacy must go hand in hand today. This is not to say that basic research is no longer needed, but it is to say that it can no longer proceed in a vacuum, and that scientists need to educate themselves and others as to the nature and implications of what they do. It also means that scientists must become much better at listening to what indigenous and other local peoples around the world have to say about what they want and need, and be more prepared to ask if and how they can be of service.

With these thoughts in mind, in 1996, an international and multicultural group of scholars and professionals created the non-governmental organization Terralingua: Partnerships for Linguistic and Biological Diversity, which is devoted to a mixture of research, information, applied work and advocacy concerning the world's linguistic diversity and its relationships with biodiversity (Box 5.1).

Among the basic principles guiding Terralingua's work are:

- that the diversity of languages and their variant forms is a vital part of the world's cultural diversity;
- that biological diversity and cultural diversity (of which linguistic diversity is a major component) are not only related, but often inseparable, perhaps causally connected through coevolution;
- that, like biological diversity, linguistic diversity (represented mostly by indigenous languages) is facing rapidly increasing threats that are causing a drastic loss of both languages and the knowledge of which they are carriers, including knowledge on the environment and sustainable resource use;
- that the continued loss of linguistic, cultural and biological diversity will have dangerous consequences for humans and the Earth; and
- that, therefore, the fate of the lands, languages and cultures of indigenous peoples is decisive for the maintenance of biodiversity and linguistic and cultural diversity.[18]

Acknowledging the link

Over the past two years, Terralingua has been striving to promote this perspective both locally and globally in support of indigenous as well as minority communities' struggle to holistically preserve and protect their linguistic, cultural and natural environments through self-determination (or local determination in the case of local communities). It is apparent that these concerted efforts are beginning to make a difference, and that recognition of the inextricable link between linguistic and biological diversity is beginning to emerge internationally. The International Society of Ethnobiology has enshrined this perspective in its Draft Code of Ethics,[19] which states that: 'Culture and language are intrinsically connected to land and territory, and cultural and linguistic diversity are inextricably linked to biological diversity', and upholds the right to preserve and protect local languages as a part of the principle of self-determination. International bodies such as UNESCO, UNEP and the UN Centre for Human Rights are turning their attention to issues of indigenous languages within the framework of biocultural diversity preservation and the protection of the rights of indigenous peoples. It is likely that in the near future the notion of linguistic diversity will become as familiar as that of cultural

Box 5.1 *Terralingua … at a glance*

'Terralingua: Partnerships for Linguistic and Biological Diversity' is an international non-profit organization dedicated to:

- Supporting the perpetuation and continued development of the world's linguistic diversity, and
- Exploring the connections between linguistic, cultural and biological diversity.

Statement of purpose

A. Terralingua recognizes:

1. That the diversity of languages and their variant forms is a vital part of the world's cultural diversity;
2. That cultural diversity and biological diversity are not only related, but often inseparable; and
3. That, like biological species, many languages and their variant forms around the world are now faced with an extinction crisis whose magnitude may well prove very large.

B. Terralingua declares:

4. That every language, along with its variant forms, is inherently valuable and therefore worthy of being preserved and perpetuated, regardless of its political, demographic or linguistic status;
5. That deciding which language to use, and for what purposes, is a basic human right inhering to members of the community of speakers now using the language or whose ancestors traditionally used it; and
6. That such usage decisions should be freely made in an atmosphere of tolerance and reciprocal respect for cultural distinctiveness – a condition that is a prerequisite for increased mutual understanding among the world's peoples and a recognition of our common humanity.

C. Therefore, Terralingua sets forth the following goals:

7. To help preserve and perpetuate the world's linguistic diversity in all its variant forms (languages, dialects, pidgins, creoles, sign languages, languages used in rituals, etc.) through research, programmes of public education, advocacy and community support.
8. To learn about languages and the knowledge they embody from the communities of speakers themselves, to encourage partnerships between community-based language/cultural groups and scientific/professional organizations who are interested in preserving cultural and biological diversity, and to support the right of communities of speakers to language self-determination.
9. To illuminate the connections between cultural and biological diversity by establishing working relationships with scientific/professional organizations and individuals who are interested in preserving cultural diversity (such as linguists, educators, anthropologists, ethnologists, cultural workers, native advocates, cultural geographers, sociologists, and so on) and those who are interested in preserving biological diversity (such as biologists, botanists, ecologists, zoologists, physical geographers, ethnobiologists, ethnoecologists, conservationists, environmental advocates, natural resource managers and so on), thus promoting the joint preservation and perpetuation of cultural and biological diversity.
10. To work with all appropriate entities in both the public and private sectors, and at all levels from the local to the international, to accomplish the foregoing.

diversity in the debates surrounding international instruments concerned with biodiversity, such as the CBD.

As this process unfolds, we are coming full circle to a holistic view of language, culture and land that may have once characterized localized human communities throughout the world, and that indigenous peoples today are holding up for the rest of humanity to see.

Notes

1 On language endangerment, see especially: Krauss, M. 1992. The world's languages in crisis. *Language* 68(1): 4–10. An integrated perspective on linguistic, cultural and biological diversity was developed in particular at the international interdisciplinary working conference 'Endangered Languages, Endangered Knowledge, Endangered Environments' (Berkeley, California, 25–27 October 1996). See: (a) Maffi, L. 1997. Language, knowledge and the environment: Threats to the world's biocultural diversity. *Anthropology Newsletter* 38(2): 11; (b) Maffi, L. (ed.). forthcoming. *Language, Knowledge and the Environment: The Interdependence of Biological and Cultural Diversity*. Submitted to Oxford University Press.

2 This article draws in part on the author's contribution to the chapter 'Linguistic Diversity', cowritten with T. Skutnabb-Kangas and J. Andrianarivo, in the forthcoming volume *Cultural and Spiritual Values of Biodiversity*, edited by Darrel Posey for the United Nations Environment Programme (UNEP).

3 For the most comprehensive catalogue of the world's languages, see: Grimes, B. (ed.). 1996. *Ethnologue: Languages of the World*. 13th edn. Summer Institute of Linguistics, Dallas. Available on the World Wide Web @ http://www.sil.org/ethnologue/. The mentioned figures do not include sign languages, that may be almost as numerous as oral languages. The data on classification of languages by number of mother-tongue speakers and relative size are from: Harmon, D. 1995. The status of the world's languages as reported in the *Ethnologue: Southwest Journal of Linguistics*, 14: 1–33. Figures 5.1–5.3 are reproduced from Harmon (1995); with the author's permission.

4 The statistics on 'nearly extinct' languages are from Harmon (1995), see note 3 above. The estimate of the possible magnitude of impending linguistic diversity loss is from: Krauss (1992), see note 1 above. For hypotheses on the historical peak of linguistic diversity, see: Hill, J.H. 1997. The meaning of linguistic diversity: Knowable or unknowable? *Anthropology Newsletter*, 38(1): 9–10. For estimates of linguistic diversity loss since the colonial era, see: Bernard, R. 1992. Preserving language diversity. *Human Organization*, 51(1): 82–9.

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7 The concept of 'linguistic ecology' described here is due to Peter Mühlhausler, building on earlier work by Einar Haugen. See: (a) Mühlhausler, P. 1996. *Linguistic Ecology: Language Change and Linguistic Imperialism in the Pacific Rim*. Routledge, London. (b) Haugen, E. 1972. *The Ecology of Language*. Stanford University Press, Stanford.

8 The correlations reported here are from: Harmon, D. in press. Losing species, losing languages: Connections between biological and linguistic diversity. *Southwest Journal of Linguistics*. Figure 5.4 and Table 5.1 are reproduced from Harmon (in press) with the author's permission. The source of biodiversity data in Table 5.1 is: McNeely, J. et al. 1990. *Conserving the World's Biological Diversity*. IUCN/WRI/CI/WWF-US/The World Bank, Gland, Washington DC. Source for linguistic-diversity data: Grimes, B. (ed.). 1992. *Ethnologue: Languages of the World*. 12th edition. Summer Institute of Linguistics, Dallas.

9 The discussion of factors of linguistic diversity-biodiversity correlations is from: Harmon (in press), note 8 above. The quote is from p. 155 of: Mühlhausler, P. 1995. The interdependence of linguistic and biological diversity. In: Myers, D. (ed.), *The Politics of Multiculturalism in the Asia/Pacific*, pp. 154–61. Northern Territory University Press, Darwin.

10 Quoted from p. 133 of: Tindale, N.B. 1974. *Aboriginal Tribes of Australia*. University of California Press, Berkeley.

11 The quote on place names is from p. 4 of: Huhn, E.S. 1996. Columbia Plateau place names: What can they teach us? *Journal of Linguistic Anthropology*, 6(1): 3–26. The expression 'wisdom sits in places' is derived from: Basso, K.H. 1996. *Wisdom Sits in Places: Landscape and Language among the Western Apache*. University of New Mexico Press, Albuquerque.

12 See Nabhan, G.P.; St Antoine, S. 1993. The loss of floral and faunal story: The extinction of experience. In: Kellett, S.R.; Wilson, E.O. (eds), *The Biophilia Hypothesis*, pp. 229–50. Island Press, Washington DC.

13 For the Piaroa study, see: Zent, S. in press. The quandary of conserving ethnoecological knowledge: A Piaroa example. In Blount, B.G.; Gragson, T.S. (eds), *Ethnoecology: Knowledge, Resources and Rights*. Georgia University Press, Athens. The Yoeme case is described in: Molina, E.S. 1998. Wa huya ania ama vutti yo'oriwa – the wilderness world is respected greatly: The Yoeme (Yaqui) truth from the Yoeme communities of Arizona and Sonora, Mexico. In: Maffi, L. (ed.), forthcoming. *Language, Knowledge and the Environment: The Interdependence of Biological and Cultural Diversity*. Submitted to Oxford University Press. The quote is from p. 18 of: Evers, L.; Molina, F.S. 1987. *Maso Bwikam/Yaqui Deer Songs: A Native American Poetry*. Sun Track and University of Arizona Press, Tucson. Figures 5.5–5.8 are reproduced from Zent (in press), with the author's permission.

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15 For a review of commonly proposed reasons for preserving languages, see: Thieberger, N. 1990. Language maintenance: Why bother? *Multilingua*, 9(4): 333–58. The quotes are from p. 82 of Bernard (1992), see note 4 above. See also: Diamond, J. 1993. Speaking with a single tongue. *Discover*, 14(2): 78–85.

16 See: (a) Reid, W.V.; Miller, K.R. 1993. *Keeping Options Alive: The Scientific Basis for Conserving the Biodiversity*. World Resources Institute, Washington DC. (b) Shiva, V. 1993. *Monocultures of*

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17 The two quotes are: (a) from p. 160 of Mühlhausler (1995), see note 7 above; (b) from p. 380 of Patanayak (1988), see note 6 above.

18 Terralingua can be reached by e-mail at: <gws@mail.portup.com>, or on the World Wide Web at: http://cougar.ucdavis.edu/nas/terralin/home.html.

19 To be submitted for approval by the membership at the Sixth International Congress of Ethnobiology, Whakatane, Aotearoa/New Zealand, 23–26 November 1998.

Part II

Early Agriculture

6

Our Vanishing Genetic Resources

Jack R. Harlan

All of the major food and fibre crops of the world are of ancient origin. The main sources of human nutrition today are contributed by such plants as wheat, rice, corn, sorghum, barley, potatoes, cassava, taro, yams, sweet potatoes and grain legumes such as beans, soybeans, peanuts, peas, chickpeas and so on. All of these plants were domesticated by Stone Age men some thousands of years ago and had become staples of the agricultural peoples of the world long before recorded history. We are not able to trace with certainty the genetic pathways that led to domestication, but we do know that these crops evolved for a long time under the guidance of man living in a subsistence agricultural economy. In the process of evolution, the domesticated forms often became strikingly different from their wild progenitors and generated enormous reserves of genetic variability.

Darwin opened his book *On the Origin of Species* with a discussion of variability of plants and animals under domestication. Genetic variability is the raw stuff of evolution, and he was struck by the range of morphological variation found in domesticated forms in contrast to their wild relatives. We are all familiar with the enormous differences among such breeds of dogs as Pekingese, dachshund, beagle, bulldog, Afghan and Great Dane and how far removed they are in appearance from either wolves or any other wild species that could have been progenitor to domestic dogs. Similar ranges of diversity are seen in chickens, pigeons, cats, cattle, horses and so on. Domestic plants exhibit the same phenomenon, especially among species that have been cultivated for a very long time and that have wide distributions. Genetic diversity is essential for evolution in nature and is, obviously, equally necessary for improvement by plant breeding.

Crop evolution through the millennia was shaped by complex interactions involving natural and artificial selection pressures and the alternate isolation of stocks followed by migrations and seed exchanges that brought the stocks into new environments and that permitted new hybridizations and recombinations of characteristics. Subsistence farmers of what we often call 'primitive' agricultural societies have an intimate knowledge of their crops and a keen eye for variation.

From Harlan J R. 1975. Our vanishing genetic resources. *Science* 188: 618–621. Reprinted with permission from AAAS.

Artificial selection is often very intense, for the only forms to survive are those that man chooses to plant. The end products that emerged in primitive agricultural systems were variable, integrated, adapted populations called land races.

While land race populations are variable, diversity is far from random. They consist of mixtures of genotypes or genetic lines, all of which are reasonably well adapted to the region in which they evolved but which differ in detail as to specific adaptations to particular conditions within the environment. They differ in reaction to diseases and pests, some lines being resistant or tolerant to certain races of pathogens and some to other races. This is a fairly effective defence against serious epiphytotics. Some components of the population are susceptible to prevalent pathogenic races, but not all, and no particular race of pathogen is likely to build up to epiphytotic proportions because there are always resistant plants in the population. Land races tend to be rather low yielding but dependable. They are adapted to the rather crude land preparation seeding, weeding and harvesting procedures of traditional agriculture. They are also adapted to low soil fertility; they are not very demanding, partly because they do not produce very much.

Land races have a certain genetic integrity. They are recognizable morphologically; farmers have names for them and different land races are understood to differ in adaptation to soil type, time of seeding, date of maturity, height, nutritive value, use and other properties. Most important, they are genetically diverse. Such balanced populations – variable, in equilibrium with both environment and pathogens, and genetically dynamic – are our heritage from past generations of cultivators. They are the result of millennia of natural and artificial selections and are the basic resources upon which future plant breeding must depend.

In addition to variable land race populations, traditional agriculture generated enormous diversity in identifiable geographic regions called 'centres of diversity' or 'gene centres'. Such centres are (or were) found on every continent, except Australia where the native people did not cultivate plants. Wherever they are located they are always characterized by (i) very ancient agriculture, (ii) great ecological diversity (usually mountainous regions), and (iii) great human diversity in the sense of numerous culturally distinct tribes with complex interacting histories. Centres of diversity were first recognized and described by the great Russian agronomist and geneticist N. I. Vavilov in the 1920s and 1930s.[1]

H. V. Harlan and M. L. Martini, concerned with genetic resources of barley, put it this way as early as 1936:

> In the great laboratory of Asia, Europe and Africa, unguided barley breeding has been going on for thousands of years. Types without number have arisen over an enormous area. The better ones have survived. Many of the surviving types are old. Spikes from Egyptian ruins can often be matched with ones still growing in the basins along the Nile. The Egypt of the Pyramids, however, is probably recent in the history of barley. In the hinterlands of Asia there were probably barley fields when man was young. The progenies of these fields with all their surviving variations constitute the world's priceless reservoir of germ plasm. It has waited through long centuries. Unfortunately, from

> the breeder's standpoint, it is now being imperiled. When new barleys replace those grown by the farmers of Ethiopia or Tibet, the world will have lost something irreplaceable.[2]

That is the way it was before World War II. Genetic erosion was already well advanced in much of Europe, the US, Canada, Japan, Australia and New Zealand, where active plant-breeding programmes had been under way for some decades. But, the ancient reservoirs of germ plasm were still there in the more remote parts of the world and seemed to most people as inexhaustible as oil in Arabia. We could afford to squander our genetic resources because we never had much of our own, and we could always send collectors to such places as Turkey, Afghanistan, Ethiopia, India, South-east Asia, China, Mexico, Colombia and Peru and assemble all the diversity we could use. No one paid much attention to the prophetic warning of Harlan and Martini.

International Programmes for Genetic Resource Conservation

After World War II, the picture began to change. Modern plant-breeding programmes were established in many of the developing nations and often right in the midst of genetically rich centres of diversity. Some of the programmes were successful, and new, uniform, high-yielding, modern varieties began to replace the old land races that had evolved over the millennia. The speed with which enormous crop diversity can be essentially wiped out is astonishing, and the slowness with which people have reacted to salvage of threatened genetic resources is dismaying.[3]

Cries of alarm began to be sounded on the international scene about 15 years ago. A short chronology of events and actions associated with the Food and Agriculture Organization (FAO) of the United Nations is presented below.

1961 FAO convened a technical meeting on plant exploration and introduction. Among the recommendations was one to the effect that a panel of experts be appointed 'to assist and advise the Director of the Plant Production and Protection Division in this field'.

1962 A proposal for a Crop Research and Introduction Centre, Izmir (Turkey), was submitted to the UN Special Fund.

1963 The twelfth session of the FAO conference also recommended the establishment of a Panel of Experts on Plant Exploration and Introduction to advise FAO on these matters.

1964 The Crop Research and Introduction Centre, Izmir, became operative with UN Special Fund support. The Centre has collected, stored and distributed germ plasm and now, under support of the Swedish government, is serving as a regional centre for the Near East.

1965 The panel of experts was appointed.
1967 FAO and the International Biological Program (IBP) jointly sponsored a Technical Conference on Exploration, Utilization and Conservation of Plant Genetic Resources.[4]
1968 A Crop Ecology and Genetic Resources Unit was established in the Plant Production and Protection Division, FAO.
1971 The Consultative Group on International Agricultural Research (CGIAR) was established under joint sponsorship of the World Bank, FAO and UN Development Programme (UNDP). Members include governments, private foundations and regional development banks, and money is generated to support international agricultural research programmes and institutes.
1971 A Technical Advisory Committee (TAG) was established to assist the CGIAR.
1972 Under joint sponsorship of TAC, FAO and CGIAR a meeting was convened at Beltsville, Maryland, and a plan for a global network of Genetic Resources Centres was drawn up. Recommendations for location and funding were made and suggestions for international organization and coordination submitted to CGIAR through TAC.
1972 The UN Stockholm Conference on the Human Environment called for action on genetic resource conservation.
1973 A second FAO/IBP technical conference was convened in Rome.[5]
1973 The CGIAR established a subcommittee on genetic resources,
1973 The International Board for Plant Genetic Resources (IBPGR) was established with a secretariat in FAO and financial resources provided by CGIAR, as recommended at the Beltsville meeting.
1974 Portions of the global strategy devised at Beltsville began to be funded through bilateral agreements with donor governments; for example, Sweden agreed to support the Izmir Centre for a time, and the Federal Republic of Germany agreed to support genetic resources centres in Ethiopia and Costa Rica. Other similar agreements have been or are being arranged.

Within the FAO structure, rather parallel developments took place with respect to forest genetic resources. Reports of technical conferences and meetings of the panel of experts, *Plant Introduction Newletter* and *Forest Genetic Resources Information* are published by FAO.

It must be admitted that for all the organizational developments, and despite repeated and urgent pleas by the panel of experts, remarkably little collecting has been done to date. The Izmir Centre has been plagued with political, financial, administrative and personnel problems from the start. It has managed to assemble a modest collection of some 10,000 accessions, and the long-term storage facilities now installed are excellent. The conception of the Izmir Centre is sound, and it is to be hoped that it will eventually perform the function for which it was established. FAO has conducted a few collecting expeditions and has given support to more, but the urgency of the situation demands much more vigorous action than has been generated so far.

The next few years, however, should show an increase in plant exploration. Funds should be available from the consultative group to support adequate exploration programmes. For some regions it will probably be too late to salvage much.

It must also be admitted that much less would have been achieved without the dogged and determined insistence of Sir Otto Frankel of Australia.[4] Through the years he has refused to abandon hope that serious action could, one day, be launched through an international cooperative programme, and he has shaped most of the events described above.

Meanwhile, the international institutes, supported largely by CGIAR, have fared somewhat better. They each deal with one or a few crops and have usually understood that a part of the mission was to assemble and preserve germ plasm of the crops being developed. The world maize collection, for example, traces back to early international agricultural research sponsored by the Rockefeller Foundation in Mexico, Colombia and elsewhere. A rather systematic effort was made to collect the races of maize, country by country, throughout Latin America. A major portion of the collection is maintained by the Centro Internacional de Mejoramento de Maíz y Trigo (CIMMYT) in Mexico, the Andean collection by the Instituto Colombiano Agropecuario (ICA) in Colombia, and the eastern South American collection is maintained at Piracicaba, Brazil. The maize collection appears to be in reasonably good shape, although some additional exploration is desirable.

The world rice collection has been growing rapidly in recent years through activities of the International Rice Research Institute (IRRI) in the Philippines. It is certainly not complete, but it is far better than it was 3 to 4 years ago. The Centro Internacional de Agricultura Tropical (CIAT) in Colombia is assembling cassava and beans. The International Institute of Tropical Agriculture (IITA) in Nigeria has been collecting cowpeas, pigeon peas, yams and other tropical tuber crops, and tropical vegetable species. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India, has assumed responsibility for world collections of sorghum, millets, chickpeas and pigeon peas. The Centro Internacional de Papas (CIP) in Peru is starting to assemble potatoes for breeding work. All of these institutes are located in the tropics and should be able to maintain and rejuvenate collections of these crops much more efficiently than can be done in temperate countries.

National Programmes: US

The agriculture of the US is an imported agriculture. Even crops domesticated by the American Indians – such as corn, potatoes, peanuts, cotton, tomatoes and so on – originated in Latin America outside of the US, and were introduced, some by Indians and some by Europeans. Because of our dependence on exotic germ plasm, the national government has sponsored collections and introductions from the beginning. As early as 1819, the Secretary of the Treasury issued a circular requesting Americans serving as consuls to send useful plant materials back to the US. Formal plant exploration was conducted by the Office of the Patent Commissioner before 1862, when the US Department of Agriculture (USDA) was created. In 1898 a Section of Seed and Plant Introduction was established in the USDA; and ever since, through various name changes and reorganizations, some unit within the department has been charged with responsibility for germ plasm assembly and maintenance.[6]

A considerable impetus was given to the plant introduction programme by the Research and Marketing Act of 1946. Regional Plant Introduction Stations were established in the four administrative regions of the country. An Inter-Regional Potato Project was established in 1949 with a special station at Sturgeon Bay, Wisconsin, where exotic potato germ plasm could be grown and evaluated. A National Seed Storage Laboratory was built in Fort Collins, Colorado, and began operation in 1958. The primary objective of the laboratory is long-term seed storage, although research on the physiology of germination, dormancy and longevity of seeds is also conducted.

Nearly 400,000 accessions have been introduced since 1898, but there has been substantial attrition over the years. The importance of maintenance was not at first generally realized, and much material was lost for one reason or another. Nevertheless, the present holdings of the USDA are very considerable and extremely important. The small grains (wheat, barley, oats and rye) collection, for example, consists of more than 60,000 items, many of which could not possibly be replaced because they have disappeared from their original homelands. Substantial 'world collections' of the major crops and many of the minor ones are being maintained at the Regional Plant Introduction Stations or through cooperative arrangements with other state and federal stations.

It would be nice to think that all the genetic diversity we will ever need is safely stored away in gene banks for future use. Unfortunately this is hardly the case. Some of our collections are large even when the numerous duplicates are accounted for, but none is really complete, and sources of diversity are drying up all over the world. We are particularly deficient in the wild and weedy relatives of our more important crops, and some geographic regions have been very poorly sampled. While the USDA has sponsored plant introduction work from the beginning, it has never been able to obtain enough support to systematically sample the world's germ plasm. The National Seed Storage Laboratory has received step-child treatment with no increase in the operating budget for more than 15 years after establishment.

The southern corn leaf blight epidemic in 1970 aroused some activity in the area of crop vulnerability. A survey was commissioned by the National Academy of Sciences, resulting in a report on genetic vulnerability.[7] It was found, not surprisingly, that not only corn but also every major crop we grow has a very narrow genetic base. The entire soybean industry, for example, traces back to six introductions from the same part of China. The leaf blight epidemic of 1970 came about because most of the hybrids produced had a common cytoplasm which conferred susceptibility to a particular race of the pathogen. We are just as vulnerable in sorghum where a cytoplasmic sterile system is used to produce hybrids. A crop-by-crop analysis reveals an extremely risky dependence on narrow genetic bases.

More than this, the number of crops we grow has been declining steadily. More and more people are being fed on fewer and fewer crops and these are becoming increasingly uniform, genetically.

After a series of meetings in Washington, an ad hoc committee drew up recommendations and presented them to the Agricultural Research Policy Advisory Committee (ARPAC) of the Agricultural Research Service. Among the recommendations was the establishment of a Genetic Resources Board at the national level which would, among other things, devise a national plan and programme for systematic assembly, maintenance, evaluation and utilization of plant genetic resources. It is to be hoped that a more systematic, coordinated and effective programme of genetic resource management can be generated for the country and that adequate financial support can be found. Approval for the board was obtained in January 1975.

National Programmes: Other Countries

The USSR probably has holdings of about the same magnitude as ours. No doubt, there is a good deal of duplication, yet they have arrays of collections that we do not have and we have materials they do not have. It would undoubtedly be of great mutual benefit if we could exchange collections and hold a complete set of duplicates in two different parts of the world. It would be a disaster if something should happen to either collection. Duplicate storage would be much safer.

National collections can be vulnerable. There is a heroic tale about the siege of Leningrad during World War II. People were dying of cold and starvation, reduced to eating rats, cats, dogs, dried glue from furniture joints and wall paper, or anything else that might prolong life. All this time, truckloads of edible seeds were in storage at the All-Union Institute of Plant Industry. The seeds were too precious to be sacrificed even at the cost of human life, and the collections survived for future use. We may pray that such a threat will never occur again, but prayer may not be adequate to save priceless genetic resources.

The Vavilovian emphasis on plant genetic resources persisted despite the long twilight of genetics under the political influence of T. D. Lysenko and Vavilov's tragic death as a result.[8] The institute, which he directed for 20 years (1920–1940), was renamed the N. I. Vavilov All-Union Institute of Plant Industry (VIR) in 1968, just in time for the 75th anniversary of the organization in 1969.[9]

There may be some question as to how well the original collections of the Vavilovian era have been maintained with respect to genetic authenticity, but there is no doubt that Soviet scientists are more collection minded than plant scientists elsewhere. Genetic resource management has been emphasized since 1920 and has become an integral part of the national agricultural development programme. No doubt there are genes in Soviet collections that no longer exist anywhere else.

The Japanese, under the stimulus of H. Kihara, have also had strong genetic conservation programmes, especially with certain crops. Expeditions have been sent to several centres of diversity over the decades and a national seed storage facility has been established at Hiratsuka. The University of Kyoto and the National Institute of Genetics, Misima, have been especially active, although others have also participated.

Genetic resources centres with cold storage for long-term conservation have been established in a number of other countries. Some of the major ones include Brisbane, Australia; Prague, Czechoslovakia; Copenhagen, Denmark; Gatersleben, German Democratic Republic; Braunschweig-Volkenröde, German Federal Republic; New Delhi, India; Bari, Italy; Wageningen, Netherlands; and Warsaw, Poland. Others are being constructed or present facilities are being upgraded. Substantial holdings are being maintained in the UK, France, Sweden, Canada and elsewhere. The necessity for genetic conservation is gradually being accepted throughout the world, but the urgency of salvage collection operations has yet to be generally appreciated.

A recent visit by a Plant Studies Delegation to the People's Republic of China revealed a somewhat ambiguous situation. The following observations may be pertinent. (i) China is, indeed, very rich in genetic diversity for many crops; (ii) Chinese scientists are not collection minded, and little effort is being made to conserve land races as they are replaced by modern varieties; (iii) the trend, at the moment, is to produce many species and varieties of fruits and vegetables, which tends to maintain diversity; and (iv) there is a strong emphasis on local self-sufficiency with respect to seed production at both the people's commune and production brigade levels which may tend to maintain variability at the national level. Overall, the picture is discouraging with respect to major crops. Two rice collections are being maintained, one for *japonica* and one for *indica* rices, but the ancient kaoliangs are disappearing from the Chinese sorghum belt, and the traditional millets are hanging on primarily in marginal dryland zones.

Altogether, a good deal has been done to collect genetic resources, and tentative, if unsystematic, steps have been taken to conserve much of it on a long-term basis. In view of the obvious limitations of our collections and in face of the current genetic 'wipe out' of centres of diversity, it may be too little and too late. We continue to act as though we could always replenish our supplies of genetic diversity. Such is not the case. The time is approaching, and may not be far off, when essentially all the genetic resources of our major crops will be found either in the crops being grown in the field or in our gene banks. This will be a risky state of affairs and will demand a great deal more time and effort on genetic resource management than we have ever devoted to it in the past.

Notes

1 Vavilov N. I. 1926. *Studies on the Origin of Cultivated Plants*. Institute of Applied Botany and Plant Breeding, Leningrad
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3 Harlan J. R. 1972. *Journal of Environ. Qual.* 1, 212
4 Frankel O. H. and Bennett E. (eds) 1970. *Genetic Resources in Plants – Their Exploration and Conservation*. FAO/IBP, Blackwell, Oxford
5 Hawkes J. G. (ed.) 1974. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press, London. This is an IBP synthesis volume and includes papers from the 1973 meeting.
6 Anon. 1971. *The National Program for Conservation of Crop Germ Plasm*. University of Georgia Press, Athens, GA
7 National Academy of Sciences. 1972. *Genetic Vulnerability of Major Crops*. National Academy of Sciences, Washington DC
8 Medvedev Z. A. 1969. *The Rise and Fall of T. D. Lysenko*, trans Lerner I. M., Columbia University Press, New York
9 Anniversary volume 1969 of *Bulletin of Applied Botany, Genetics and Plant Breeding* 41, fasc.1

7

Oriental Despotism

K. Wittfogel

The characteristics of hydraulic economy are many, but three are paramount. Hydraulic agriculture involves a specific type of division of labour. It intensifies cultivation. And it necessitates cooperation on a large scale. The third characteristic has been described by a number of students of Oriental farming. The second has been frequently noted, but rarely analysed. The first has been given practically no attention. This neglect is particularly unfortunate, since the hydraulic patterns of organization and operation have decisively affected the managerial role of the hydraulic state.

Economists generally consider the division of labour and cooperation key prerequisites of modern industry, but they find them almost completely lacking in farming.[1] Their claim reflects the conditions of Western rainfall agriculture. For this type of agriculture it is indeed by and large correct.

However, the economists do not as a rule so limit themselves. Speaking of agriculture without any geographical or institutional qualification, they give the impression that their thesis, being universally valid, applies to hydraulic as well as to hydroagriculture and rainfall farming. Comparative examination of the facts quickly discloses the fallacy of this contention.

A. Division of Labour in Hydraulic Agriculture

1. Preparatory and protective operations separated from farming proper

What is true for modern industry – that production proper depends on a variety of preparatory and protective operations[2] – has been true for hydraulic agriculture since its beginnings. The peculiarity of the preparatory and protective hydraulic operations is an essential aspect of the peculiarity of hydraulic agriculture.

Reprinted from Wittfogel K. 1957. *Oriental Despotism*. Yale University Press, New Haven, Chapter 2, pp22–48.

a. Large-scale preparatory operations (Purpose: irrigation)

The combined agricultural activities of an irrigation farmer are comparable to the combined agricultural activities of a rainfall farmer. But the operations of the former include types of labour (on-the-spot ditching, damming and watering) that are absent in the operations of the latter. The magnitude of this special type of labour can be judged from the fact that in a Chinese village a peasant may spend from 20 to over 50 per cent of his work time irrigating, and that in many Indian villages irrigation is the most time-consuming single item in the farmer's budget.[3]

Hydroagriculture (small-scale irrigation farming) involves a high intensity of cultivation on irrigated fields – and often also on non-irrigated fields.[4] But it does not involve a division of labour on a communal, territorial or national level. Such a work pattern occurs only when large quantities of water have to be manipulated. Wherever, in pre-industrial civilizations, man gathered, stored and conducted water on a large scale, we find the conspicuous division between preparatory (feeding) and ultimate labour characteristic of all hydraulic agriculture.

b. Large-scale protective operations (Purpose: flood control)

But the fight against the disastrous consequences of too little water may involve a fight against the disastrous consequences of too much water. The potentially most rewarding areas of hydraulic farming are arid and semi-arid plains and humid regions suitable for aquatic crops, such as rice, that are sufficiently low-lying to permit watering from nearby rivers. These rivers usually have their sources in remote mountains, and they rise substantially as the summer sun melts part of the snow accumulated there.

Upstream developments of this kind cause annual inundations in Egypt, Mesopotamia, Turkestan, India, China and in the Andean and Mexican zones of America. In semi-arid areas on-the-spot rains create additional dangers when they are overconcentrated (convectional) or irregular. This condition prevails in North China, northern Mesopotamia (Assyria) and the Mexican lake region. Thus a hydraulic community that resorts to preparatory labour to safeguard the productive use of water may also have to resort to protective labour to safeguard its crops from periodic and excessive inundations.

When, in protohistorical times, the Chinese began to cultivate the great plains of North China, they quickly recognized that the centres of greatest potential fertility were also the centres of greatest potential destruction. To quote John Lossing Buck: 'Geologically speaking, man has settled these plains thousands of years before they were ready for occupation.'[5] The Chinese built huge embankments which, although unable to remove entirely the risk inhering in the ambivalent situation, matched and even surpassed in magnitude the area's preparatory (feeding) works.[6]

In India enormous problems of flood control are posed by the Indus River[7] and, in a particularly one-sided way, by the Ganges and Brahmaputra Rivers, which in Bengal create optimal conditions for the cultivation of rice and maximal dangers from floods. By 1900 Bengal boasted 97 miles of larger irrigation canals and 1298 miles of embankments.[8]

In ancient Mesopotamia even watchful rulers could not completely prevent the inundations from damaging the densely settled plains.[9] In Turkestan excessive floods periodically threatened the Zarafshan River Valley.[10] In Upper Egypt the Nile, in very high flood, rises 1 metre above the level of the settled countryside, in Middle Egypt 2 metres, and in the Delta area up to 3.5 metres.[11] The inhabitants of the lake area of Mexico could benefit from its fertility only if they accepted the periodic overflow of its short, irregular, narrow streams,[12] which they sought to control through a variety of protective works. Thus in virtually all major hydraulic civilizations, preparatory (feeding) works for the purpose of irrigation are supplemented by and interlocked with protective works for the purpose of flood control.

2. Cooperation

A study of the hydraulic patterns of China (especially North China), India, Turkestan, Mesopotamia (especially Assyria), Egypt or Meso-America (especially the Mexican lake region) must therefore consider both forms of agrohydraulic activities. Only by proceeding in such a way can we hope to determine realistically the dimension and character of their organizational key device: cooperation.

a. Dimension

When a hydraulic society covers only a single locality, all adult males may be assigned to one or a few communal work teams. Varying needs and circumstances modify the size of the mobilized labour force. In hydraulic countries having several independent sources of water supply, the task of controlling the moisture is performed by a number of separated work teams.

Among the Hill Suk of East Africa, 'every male must assist in making the ditches'.[13] In almost all Pueblos 'irrigation or cleaning a spring is work for all'.[14] Among the Chagga, the maintenance of a relatively elaborate irrigation system is assured by 'the participation of the entire people'.[15] In Bali the peasants are obliged to render labour service for the hydraulic regional unit, the *subak*, to which they belong.[16] The masters of the Sumerian temple economy expected every adult male within their jurisdiction 'to participate in the digging and cleaning of the canals'.[17] Most inscriptions of Pharaonic Egypt take this work pattern for granted. Only occasionally does a text specify the character of the universally demanded activities, among which lifting and digging are outstanding.[18]

In imperial China every commoner family was expected on demand to provide labour for hydraulic and other public services. The political and legal writings of India indicate a similar claim on corviable labour.[19] The laws of Inca Peru obliged all able-bodied men to render *corvée* service.[20] In ancient Mexico both commoner and upper-class adolescents were instructed in the techniques of digging and damming.[21] At times the masters of this hydraulic area levied the manpower of several territorial states for their gigantic hydraulic enterprises.[22]

In 19th-century Egypt 'the whole corviable population' worked in four huge shifts on Mehmed Ali's hydraulic installations. Each group laboured on the canals for 45 days until, after 180 days, the job was completed.[23] From 1881 on, at a time of decay and disintegration, 'the *whole* of the corvée fell on the poorest classes',[24] the smaller number being compensated for by an increase in the labour-time to 90 days. In some regions the conscripts were kept busy 'for 180 days'.[25]

b. Integration

Orderly cooperation involves planned integration. Such integration is especially necessary when the objectives are elaborate and the cooperating teams large.

Above the tribal level, hydraulic activities are usually comprehensive. Most writers who mention the cooperative aspect of hydraulic agriculture think in the main of digging, dredging and damming; and the organizational tasks involved in these labours is certainly considerable. But the planners of a major hydraulic enterprise are confronted with problems of a much more complex kind. How many persons are needed? And where can such persons be found? On the basis of previously made registers, the planners must determine the quota and criteria of selection. Notification follows selection, and mobilization notification. The assembled groups frequently proceed in quasimilitary columns. Having reached their destination, the buck privates of the hydraulic army must be distributed in proper numbers and according to whatever division of operations (spading, carrying of mud, etc.) is customary. If raw materials such as straw, faggots, lumber or stone have to be procured, auxiliary operations are organized; and if the work teams – *in toto* or in part – must be provided with food and drink, still other ways of appropriation, transport and distribution have to be developed. Even in its simplest form, agrohydraulic operations necessitate substantial integrative action. In their more elaborate variations, they involve extensive and complex organizational planning.

c. Leadership

All teamwork requires team leaders; and the work of large integrated teams requires on-the-spot leaders and disciplinarians as well as overall organizers and planners. The great enterprises of hydraulic agriculture involve both types of direction. The foreman usually performs no menial work at all; and except for a few engineering specialists the sergeants and officers of the labour force are essentially organizers.

To be sure, the physical element – including threats of punishment and actual coercion – is never absent. But here, if anywhere, recorded experience and calculated foresight are crucial. It is the circumspection, resourcefulness and integrative skill of the supreme leader and his aides which play the decisive role in initiating, accomplishing and perpetuating the major works of hydraulic economy.

d. Hydraulic leadership – political leadership

The effective management of these works involves an organizational web which covers either the whole, or at least the dynamic core, of the country's population. In consequence, those who control this network are uniquely prepared to wield supreme political power.

From the standpoint of the historical effect, it makes no difference whether the heads of a hydraulic government were originally peace chiefs, war leaders, priests, priest-chiefs or hydraulic officials *sans phrase*. Among the Chagga, the hydraulic corvée is called into action by the same horn that traditionally rallied the tribesmen for war.[26] Among the Pueblo Indians the war chiefs (or priests), although subordinated to the *cacique* (the supreme chief), direct and supervise the communal activities.[27] The early hydraulic city states of Mesopotamia seem to have been for the most part ruled by priest-kings. In China the legendary trail blazer of governmental water control, the Great Yü, is said to have risen from the rank of a supreme hydraulic functionary to that of king, becoming, according to protohistorical records, the founder of the first hereditary dynasty, Hsia.

No matter whether traditionally nonhydraulic leaders initiated or seized the incipient hydraulic 'apparatus', or whether the masters of this apparatus became the motive force behind all important public functions,[28] there can be no doubt that in all these cases the resulting regime was decisively shaped by the leadership and social control required by hydraulic agriculture.

B. Heavy Water Works and Heavy Industry

With regard to operational form, hydraulic agriculture exhibits important similarities to heavy industry. Both types of economic activities are preparatory to the ultimate processes of production. Both provide the workers with essential material for these ultimate processes. And both tend to be comprehensive, 'heavy'. For these reasons the large enterprises of hydraulic agriculture may be designated as 'heavy water works'.

But the dissimilarities are as illuminating as the similarities. The heavy water works of hydraulic agriculture and the heavy industry of modern economy are distinguished by a number of basic differences, which, properly defined, may aid us in more clearly recognizing the peculiarities of hydraulic society.

Heavy water works feed the ultimate agrarian producer one crucial auxiliary material: water; heavy industry provides auxiliary and raw materials of various kinds, including tools for finishing and heavy industry. Heavy water works fulfil important protective functions for the country at large; the protective installations (buildings, etc.) of industry do not. Heavy water works cover at their inception a relatively large area; and with the development of the hydraulic order they are usually spread still further. The operations of heavy industry are spatially much more restricted. At first, and for a number of preliminary processes, they may depend on small and dispersed shops; with the growth of the industrial order they tend to merge into one, or a few, major establishments.

The character of the labour force varies with these spatial and operational differences. Heavy water works are best served by a widely distributed personnel, whereas heavy industry requires the workers to reside near the locally restricted 'big' enterprises which employ them. The hydraulic demand is satisfied by adult peasant males, who continue to reside in their respective villages; whereas the industrial demand is satisfied by a geographically concentrated labour force.

The bulk of the hydraulic workers are expected to remain peasants, and in most cases they are mobilized for a relatively short period only – at best for a few days, at worst for any time that will not destroy their agricultural usefulness. Thus division of agrohydraulic labour is not accompanied by a corresponding division of labourers.

The contrast to the labour policy of heavy industry is manifest. Different from heavy water works, which may be created and maintained during a fraction of the year, heavy industry operates most effectively when it operates continuously. The industrial employers prefer to occupy their personnel throughout the year; and with the growth of the industrial system full-time labour became the rule. Thus division of industrial labour moves toward a more or less complete division of labourers.

The two sectors are also differently administered. In the main, modern heavy industry is directed by private owners or managers. The heavy water works of hydraulic agriculture are directed essentially by the government. The government also engages in certain other large enterprises, which, in varying combinations, supplement the agrohydraulic economy proper.

C. Calendar Making and Astronomy – Important Functions of the Hydraulic Regime

Among the intellectual functions fulfilled by the leaders of agrohydraulic activities, some are only indirectly connected with the organization of men and material; but the relation is highly significant nevertheless. Time keeping and calendar making are essential for the success of all hydraulic economies; and under special conditions special operations of measuring and calculating may be urgently needed.[29] The way in which these tasks are executed affect both the political and the cultural development of hydraulic society.

To be sure, man is deeply concerned about the swing of the seasons under all forms of extractive economy and throughout the agrarian world. But in most cases he is content to determine in a general way when spring or summer begin, when cold will set in, when rain or snow will fall. In hydraulic civilizations such general knowledge is insufficient. In areas of full aridity it is crucial to be prepared for the rise of the rivers whose overflow, properly handled, brings fertility and life and whose unchecked waters leave death and devastation in their wake. The dykes have to be repaired in the proper season so that they will hold in times of inundation; and the canals have to be cleaned so that the moisture will be satisfactorily distributed. In semi-arid areas receiving a limited or uneven rainfall an accurate calendar is similarly important. Only when the embankments, canals and reservoirs are ready and in good condition can the scanty precipitation be fully utilized.

The need for reallocating the periodically flooded fields and determining the dimension and bulk of hydraulic and other structures provide continual stimulation for developments in geometry and arithmetic. Herodotus ascribes the beginnings of geometry in Egypt to the need for annually remeasuring the inundated land.[30]

No matter whether the earliest scientific steps in this direction were made in the Nile Valley or in Mesopotamia, the basic correlation is eminently plausible. Obviously the pioneers and masters of hydraulic civilization were singularly well equipped to lay the foundations for two major and interrelated sciences: astronomy and mathematics.

As a rule, the operations of time keeping and scientific measuring and counting were performed by official dignitaries or by priestly (or secular) specialists attached to the hydraulic regime. Wrapped in a cloak of magic and astrology and hedged with profound secrecy, these mathematical and astronomical operations became the means both for improving hydraulic production and bulwarking the superior power of the hydraulic leaders.

D. Further Construction Activities Customary in Hydraulic Societies

The masters of the hydraulic state did not confine their activities to matters immediately connected with agriculture. The methods of cooperation which were so effective in the sphere of crop-raising were easily applied to a variety of other large tasks.

Certain types of works are likely to precede others. Generally speaking, the irrigation canal is older than the navigation canal; and hydraulic digging and damming occurred prior to the building of highways. But often derivative steps were taken before the original activities had progressed far, and different regional conditions favoured different evolutionary sequences. Thus the divergencies of interaction and growth are great. They include many constructional activities above and beyond the sphere of hydraulic agriculture.[31]

1. Nonagrarian hydraulic works

a. Aqueducts and reservoirs providing drinking water

A commonwealth able to transfer water for purposes of irrigation readily applies its hydraulic know-how to the providing of drinking water. The need for such action was slight in the greater part of Medieval Europe, where the annual precipitation furnished sufficient ground water for the wells on which most towns depended for their water supply.[32]

Even in the hydraulic world, drinking water is not necessarily an issue. Wherever rivers, streams or springs carry enough moisture to satisfy the drinking needs of the population throughout the year, no major problem arises. The inhabitants of the Nile and Ganges Valleys and of many similar areas did not have to construct elaborate aqueducts for this purpose.

The irregular flow of rivers or streams or the relatively easy access to fresh and clear mountain water has stimulated in many hydraulic landscapes the construction of comprehensive installations for the storage and distribution of drinking water. In America great aqueducts were built by the hydraulic civilizations of the Andean zone and Meso-America.[33] The many reservoirs (tanks) of Southern India frequently serve several uses; but near the large residential centres the providing of drinking water is usually paramount. In certain areas of the Near East, such as Syria and Assyria, brilliantly designed aqueducts have satisfied the water needs of many famous cities, Tyre,[34] Antioch[35] and Nineveh[36] among them. In the Western world of rainfall agriculture, aqueducts were built primarily by such Mediterranean peoples as the Greeks and the Romans, who since the dawn of history maintained contact with – and learned from – the technically advanced countries of Western Asia and North Africa. No doubt the Greeks and Romans would have been able to solve their drinking-water problem without inspiration from the outside; but the form of their answer strongly suggests the influence of Oriental engineering.[37]

b. Navigation canals

Among the great agrarian conformations of history, only hydraulic society has constructed navigation canals of any major size. The seafaring Greeks, making the Mediterranean their highway, avoided an issue which the ancient city states were poorly equipped to handle. The not-too-numerous Roman canals were apparently all dug at a time when the growing Orientalization of the governmental apparatus stimulated, among other things, a growing interest in all kinds of public works.[38]

The rainfall farmers of Medieval Europe, like their counterparts elsewhere, shunned rather than sought the marshy river lowlands. And their feudal masters paid little attention to the condition of the watercourses, for which they had no use. Still less did they feel obliged to construct additional and artificial rivers – canals. Few if any important canals were built during the Middle Ages,[39] and medieval trade and transport were seriously handicapped by the state of the navigable rivers.[40]

It was in connection with the rise of a governmentally encouraged commercial and industrial capitalism that the West began to build canals on a conspicuous scale. The 'pioneer of the canals of modern Europe', the French Canal du Midi, was completed only in the second half of the 17th century, in 1681,[41] that is, little more than a century before the end of the absolutist regime. And in the classical country of inland navigation, England,[42] 'little … was done in making canals … until the middle of the eighteenth century'[43] – that is, until a time well after the close of England's absolutist period and immediately prior to the beginning of the machine age.

As stated above, the members of a hydraulic commonwealth felt quite differently about the management of natural and artificial watercourses. They approached the fertility-bearing rivers as closely as possible, and in doing so they had to find ways of draining the lowland marshes and strengthening and reshaping the river banks. Naturally the question of inland navigation did not arise everywhere. Existing rivers and streams might be suitable for irrigation, but not for shipping (Pueblos, Chagga, Highland Peru); or the ocean might prove an ideal means of transportation (Hawaii, Coastal Peru). In certain localities inland navigation was satisfactorily served by man-managed rivers (Egypt, India) and lakes (Mexico) plus whatever irrigation canals were large enough to accommodate boats (Mesopotamia).

But when supplementary watercourses were not only possible but desirable, the organizers of agrohydraulic works had little difficulty in utilizing their cooperative 'apparatus' to make them available. The new canals might be only minor additions to the existing watercourses. The ancient Egyptians constructed canals in order to circumnavigate impassable cataracts, and they temporarily connected the Nile and the Red Sea;[44] but these enterprises had little effect on the overall pattern of the country's hydraulic economy. In other instances, navigation canals assumed great importance. They satisfied the needs of the masters of the hydraulic state: the transfer of parts of the agrarian surplus to the administrative centres and the transport of messengers and troops.

In Thailand (Siam) the different hydraulic tasks overlapped. In addition to the various types of productive and protective hydraulic installations, the government constructed in the centres of rice production and state power a number of canals, which essentially served as 'waterways', that is, as a means for transporting the rice surplus to the capital.[45]

The corresponding development in China is particularly well documented. In the large plains of North China the beginnings of navigation canals go back to the days of the territorial states – that is, to the period prior to 221 BC, when the various regional governments were still administered by officials who were given office lands in payment for their services. The difference between the state-centred system of land grants as it prevailed in early China and the knighthood feudalism of Medieval Europe is spectacularly demonstrated by the almost complete absence of public works in feudal Europe and the enormous development of such works – hydraulic and otherwise – in the territorial states of China.[46]

The geographical and administrative unification of China which vastly increased the political need for navigation canals also increased the state's organizational power to build them. The first centuries of the empire saw a great advance not only in the construction of irrigation canals,[47] reservoirs, and protective river dikes but also in the digging of long canals for administrative and fiscal purposes.[48]

When, after several centuries of political fragmentation, the Sui rulers at the end of the 6th century again unified 'all-under-heaven', they bulwarked the new political structure by creating out of earlier and substantial beginnings the gigantic Imperial Canal, significantly known in China as Yün Ho, 'the Transport Canal'. This canal extends today for about 800 miles, its length equalling the distance from the American-Canadian Great Lakes to the Gulf of Mexico or – in European terms – the distance from Berlin to Bordeaux or from Hamburg to Rome. For labour on part of this gigantic water work the Sui government mobilized in the regions north of the Yellow River alone 'more than a million of men and women',[49] that is, almost one-half of the total population which England is said to have had from the 14th to the 16th century.[50]

The gigantic effort involved in banking the rivers and building the canals of China is indicated by the American agronomist, F. H. King, who conservatively estimates the combined lengths of the man-managed watercourses of China, Korea and Japan at some 200,000 miles. 'Forty canals across the United States from east to west and sixty from north to south would not equal in number of miles those in these three countries today. Indeed, it is probable that this estimate is not too large for China alone.'[51]

2. Large nonhydraulic constructions

a. Huge defence structures

The need for comprehensive works of defence arises almost as soon as hydraulic agriculture is practised. Contrary to the rainfall farmer, who may shift his fields with relative ease, the irrigation farmer finds himself depending on an unmovable, if highly rewarding, source of fertility. In the early days of hydraulic cultivation reliance on a fixed system of water supply must in many cases have driven the agrarian community to build strong defences around its homes and fields.

For this purpose hydraulic agriculture proved suggestive in two ways: it taught man how to handle all kinds of building materials, earth, stone, timber, etc., and it trained him to manipulate these materials in an organized way. The builders of canals and dams easily became the builders of trenches, towers, palisades and extended defence walls.

In this, as in all corresponding cases, the character and magnitude of the operations were determined by internal and external circumstances. Surrounded by aggressive neighbours, the Pueblo Indians ingeniously utilized whatever building material was at hand to protect their settlements, which rarely comprised more than a few hundred inhabitants.[52] The fortress-like quality of their villages is manifest to the present-day anthropologist; it struck the Spanish *conquistadores*, who were forced at times to besiege a single settlement for days and weeks before they could take it.[53] Rigid cooperation assured security of residence, just as it assured success in farming. An early observer stresses this aspect of Pueblo life: 'They all work together to build the villages.'[54]

The Chagga were equally effective in the transfer of their hydraulic work patterns to military constructions. Their great chieftain, Horombo (*fl.* 1830), used 'thousands of people' to build great fortifications, which in part still stand today.[55] 'The walls of these fortifications are some six feet high, and in length 305 yards on the south side, 443 yards on the north, 277 yards on the east side, and 137 yards on the west side.'[56] Tunnels, extended trenches and dugouts added to the defence of the walled settlements, which appeared early in the history of the Chagga.[57]

'Deep dugouts excavated under the huts, and often leading into underground passages with outlets at some distance, were used for refuge. Almost every country was secured with great war trenches, which are everywhere to be seen at the present day and are often still of great depth.'[58]

These instances show what even primitive hydraulic societies could achieve in the field of defence construction, when they strained their cooperative resources to the full. Higher hydraulic societies employed and varied the basic principle in accordance with technical and institutional circumstances.

In pre-Columbian Mexico the absence of suitable labour animals placed a limitation on transport, and while this restricted siege craft, it did not preclude the struggle for or the defence of the cities. In emergencies many government-built hydraulic works in the main lake area fulfilled military functions, just as the monster palaces and temples served as bastions against an invading enemy.[59] Recent research draws attention to various types of Mexican forts and defence walls.[60] Because of their size and importance, they may safely be adjudged as state-directed enterprises. The colossal fortresses and walls of pre-Spanish Peru, which astonished early and recent observers,[61] are known to have been built at the order of the government and by 'incredibly' large teams of corvée labourers.[62]

Many texts and pictorial representations have portrayed the walls, gates and towers of ancient Egypt, Sumer, Babylonia, Assyria and Syria. The *Arthashāstra* indicates the systematic manner in which the rulers of the first great Indian empire treated problems of fortification and defence.[63] At the dawn of Chinese history new capitals were created at the ruler's command, and during the last centuries of the Chou period the territorial states used their corviable manpower to wall entire frontier regions, not only against the tribal barbarians but also against each other. In the 3rd century BC the unifier of China, Ch'in Shih Huang-ti, linked together and elaborated older territorial structures to form the longest unbroken defence installation ever made by man.[64] The periodic reconstruction of the Chinese Great Wall expresses the continued effectiveness of hydraulic economy and government-directed mass labour.

b. Roads

The existence of government-made highways is suggested for the Babylonian period;[65] it is documented for Assyria.[66] And the relationship between these early constructions and the roads of Persia, the Hellenistic states and Rome seems 'beyond doubt'.[67] The great Persian 'royal road' deeply impressed the contemporary Greeks;[68] it served as a model for the Hellenistic rulers,[69] whose efforts in turn inspired the official road builders of the Roman empire.[70] According to Mez, the Arabs inherited 'the type of "governmental road", like its name, from the Persian "Royal Road".'[71] Beyond this, however, they showed little interest in maintaining good roads, probably because they continued to rely in the main on camel caravans for purposes of transport. The later Muslim regimes of the Near East used highways, but they never restored them to the state of technical perfection which characterized the pre-Arab period.[72]

Roads were a serious concern of India's vigorous Maurya kings.[73] A 'royal road' of 10,000 *stadia*, which is said to have led from the capital to the north-western border, had a system of marking distances which, in a modified form, was again employed by the Mogul emperors.[74] In Southern India, where Hindu civilization was perpetuated for centuries after the north had been conquered, government-made roads are mentioned in the inscriptions; and 'some of them are called king's highways'.[75] The Muslim rulers of India continued the Indian rather than the West Asian pattern in their effort to maintain a network of state roads.[76] Sher Shāh (*d.* 1545) built four great roads, one of which ran from Bengal to Agra, Delhi and Lahore.[77] Akbar is said to have been inspired by Sher Shāh when he built a new 'king's highway', called the Long Walk, which for 400 miles was 'shaded by great trees on both sides'.[78]

In China, a gigantic network of highways was constructed immediately after the establishment of the empire in 221 BC. But in this case, as in the cases of the irrigation and navigation canals or the long defence walls, the imperial engineers systematized and elaborated only what their territorial predecessors had initiated. Long before the 3rd century BC an efficient territorial state was expected to have well kept overland highways, supervised by central and local officials, lined with trees, and provided with stations and guest houses.[79] Under the empire, great state roads connected all the important centres of the northern core area with the capital. According to the official *History of the Han Dynasty*, the First Emperor

> built the Imperial Road throughout the empire. To the east it stretched to Yen and Ch'i and to the south it reached Wu and Ch'u. The banks and the shore of the Chiang [the Yangtze River] and the lakes and the littoral along the sea coast were all made accessible. The highway was fifty paces wide. A space three *chang* [approximately twenty-two feet] wide in the center was set apart by trees. The two sides were firmly built, and metal bars were used to reinforce them. Green pine trees were planted along it. He constructed the Imperial Highway with such a degree of elegance that later generations were even unable to find a crooked path upon which to place their feet.[80]

In the subsequent dynasties the building and maintenance of the great trunk roads and their many regional branches remained a standard task of China's central and local administration.

The rugged terrain of Meso-America and the absence of fully coordinated empires seems to have discouraged the construction of highways during the pre-Columbian period, at least on the high plateau. But the Andean area was the scene of extraordinary road building. The Spanish conquerors described in detail the fine highways which crossed both the coastal plain and the highlands and which formed connecting links between them.[81] Commenting on the Andean roads, Hernando Pizarro writes he never saw their like in similar terrain 'within the entire Christian world'.[82] In fact the only parallel he could think of was the system of highways built by the Romans. The similarity is telling. As we shall discuss below, the extensive Roman roads were the fruits of a fateful transformation that made the Roman Empire a Hellenistically (Orientally) despotic state.

The efforts required to build all these great highways have attracted much less attention than the finished products. But what evidence we have indicates that like most other major government enterprises, they were mainly executed through the cooperative effort of state-levied corvée labourers. Under the Inca empire supervisory officials marked off the land and informed the local inhabitants 'that they should make these roads'. And this was done with little cost to the government. The commandeered men 'come with their food and tools to make them'.[83]

The highways of imperial China required an enormous labour force for their construction and a very sizable one for their maintenance. A Han inscription notes that the construction of a certain highway in the years AD 63–66 occupied 766,800 men. Of this great number only 2690 were convicts.[84]

c. Palaces, capital cities and tombs

A governmental apparatus capable of executing all these hydraulic and nonhydraulic works could easily be used in building palaces and pleasure grounds for the ruler and his court, palace-like government edifices for his aides, and monuments and tombs for the distinguished dead. It could be used wherever the equalitarian conditions of a primitive tribal society yielded to tribal or no-longer tribal forms of autocracy.

The head chief of a Pueblo community had his fields worked for him by the villagers. But apparently his dwelling did not differ from the houses of other tribesmen, except perhaps that it was better and more securely located. The Chagga chieftains had veritable palaces erected for their personal use; and the corvée labour involved in their construction was substantial.[85]

The colossal palaces of the rulers of ancient Peru were erected by the integrated manpower of many labourers. In pre-Columbian Mexico, Nezahualcoyotzin, the king of Tezcuco, the second largest country in the Aztec Federation, is said to have employed more than 200,000 workers each day for the building of his magnificent palace and park.[86]

Unlimited control over the labour power of their subjects enabled the rulers of Sumer, Babylon and Egypt to build their spectacular palaces, gardens and tombs. The same work pattern prevailed in the many smaller states that shaped their government on the Mesopotamian or Egyptian model. According to the biblical records, King Solomon built his beautiful temple with labour teams that, like those of Babylonia, were kept at work for four months of the year.[87]

The great edifices of Mogul India have been frequently described. Less known but equally worthy of mention are the constructions of the earlier periods. The third ruler of the Tughluq, Fīrūs Shāh (*ca.* 1308–1388), dug several important irrigation canals, the famous 'Old Jumna Canal' among them. He built forts, palaces, and palace-cities, mosques and tombs. The palace-fort of Kotla Fīrūs Shāh, which rose in his new capital of Fīrūsābād (Delhi), faithfully preserved the grand style of pre-Islamic Indian and Eastern architecture.[88]

The Chinese variant of the general agromanagerial building trend is revealed in many elaborate works. The First Emperor of China, Ch'in Shih Huang-ti, began to build great hydraulic works in the early days of his power; and in the course of his reign he completed colossal works of the nonhydraulic public and semi-private types. Having destroyed all his territorial rivals, he constructed the previously mentioned network of highways which gave his officials, messengers and troops easy access to all regions of his far-flung empire. Later he defended himself against the northern pastoralists by consolidating the Great Wall. Palaces for his personal use had been built in the early days of his reign; but it was only in 213 BC that work was begun on his superpalace. This monster project, together with the construction of his enormous tomb,[89] is said to have occupied work teams numbering over 700,000 persons.[90]

Eight hundred years later the second monarch of a reunified China, Emperor Yang (604–17) of the Sui Dynasty, mobilized a still larger labour force for the execution of similar monster enterprises. In addition to the more than 1 million persons – men and women – levied for the making of the Grand Canal,[91] he dispatched huge corvée teams to extend the imperial roads[92] and to work on the Great Wall. According to the *History of the Sui Dynasty*, over a million persons toiled at the Great Wall.[93] According to the same official source, the construction of the new eastern capital, which included a gigantic new imperial palace, involved no less than 2 million people 'every month'.[94]

d. Temples

The position, fate and prestige of the secular masters of hydraulic society were closely interlinked with that of their divine protectors. Without exception, the political rulers were eager to confirm and bulwark their own legitimacy and majesty by underlining the greatness of their supernatural supporters. Whether the government was headed by secular monarchs or priest-kings, the commanding centre made every effort to provide the supreme gods and their earthly functionaries with adequate surroundings for worship and residence.

Government-directed work teams, which erected gigantic palaces, were equally fitted to erect gigantic temples. Ancient inscriptions note the many temples built by the Mesopotamian rulers.[95] Usually the sovereign speaks as if these achievements resulted solely from his personal efforts. But occasional remarks indicate the presence of 'the people' who toiled 'according to the established plan'.[96] Similarly, most Pharaonic texts refer to the final achievement[97] or to the greatness of the directing sovereign;[98] but again a number of texts refer to the government-led labour forces, 'the people'.[99]

In the agromanagerial cultures of pre-Columbian America, buildings for religious purposes were particularly conspicuous. Native tradition as well as the early Spanish accounts emphasize the tremendous labour required to construct and maintain the sacred houses and pyramids. The Mexicans coordinated their communal energies to erect the first temple for the newly established island city, the later Aztec capital;[100] and their increasingly powerful descendants mobilized the manpower of many subjugated countries for the construction of increasingly huge temples.[101] The city-like palace of the famous King of Tezcuco, Nezahualcoyotzin, contained no less than 40 temples.[102] The great number of labourers engaged in building this palace- and temple-city has already been cited. Like the monster work teams of Mexico, those of Tezcuco could draw upon the entire corviable population.[103] In another country of the main lake region, Cuauhtitlan, the construction of large-scale hydraulic works[104] was followed by the building of a great temple. It took 13 years to complete the second task.[105]

In the Andean zone, as in most other areas of the hydraulic world, the attachment of the priesthood to the government is beyond doubt. The Incas made heavy levies on their empire's material wealth in order to beautify their temples and pyramids.[106] They called up whatever manpower was needed to collect the raw material, transport it and do the actual work of construction.[107]

E. The Masters of Hydraulic Society – Great Builders

Evidently the masters of hydraulic society, whether they ruled in the Near East, India, China or pre-Conquest America, were great builders. The formula is usually invoked for both the aesthetic and the technical aspect of the matter; and these two aspects are indeed closely interrelated. We shall briefly discuss both of them with regard to the following types of hydraulic and nonhydraulic construction works:

- I. Hydraulic works
    - A. Productive installations
      (Canals, aqueducts, reservoirs, sluices and dikes for the purpose of irrigation)
    - B. Protective installations
      (Drainage canals and dikes for flood control)
    - C. Aqueducts providing drinking water
    - D. Navigation canals
- II. Nonhydraulic works
    - A. Works of defence and communication
        1. Walls and other structures of defence
        2. Highways
    - B. Edifices serving the public and personal needs of the secular and religious masters of hydraulic society
        1. Palaces and capital cities
        2. Tombs
        3. Temples

1. The aesthetic aspect

a. Uneven conspicuousness

The majority of persons who have commented on the great builders of Asia and ancient America are far more articulate on the nonhydraulic than on the hydraulic achievements. Within the hydraulic sphere more attention is again given to the aqueducts for drinking water and the navigation canals than to the productive and protective installations of hydraulic agriculture. In fact, these last are frequently overlooked altogether. Among the nonhydraulic works, the 'big houses' of power and worship and the tombs of the great are much more carefully investigated than are the large installations of communication and defence.

This uneven treatment of the monster constructions of hydraulic society is no accident. For functional, aesthetic and social reasons the hydraulic works are usually less impressive than the nonhydraulic constructions. And similar reasons encourage uneven treatment also within each of the two main categories.

Functionally speaking, irrigation canals and protective embankments are widely and monotonously spread over the landscape, whereas the palaces, tombs and temples are spatially concentrated. Aesthetically speaking, most of the hydraulic works are undertaken primarily for utilitarian purposes, whereas the residences of the rulers and priests, the houses of worship and the tombs of the great are meant to be beautiful. Socially speaking, those who organize the distribution of manpower and material are the same persons who particularly and directly enjoy the benefits of many nonhydraulic structures. In consequence they are eager to invest a maximum of aesthetic effort in these structures (palaces, temples and capital cities) and a minimum of such effort in all other works.

Of course, the contrast is not absolute. Some irrigation works, dikes, aqueducts, navigation canals, highways and defence walls do achieve considerable functional beauty. And closeness to the centres of power may lead the officials in charge to construct embankments, aqueducts, highways, bridges, walls, gates and towers with as much care for aesthetic detail as material and labour permit.

But these secondary tendencies do not alter the two basic facts that the majority of all hydraulic and nonhydraulic public works are aesthetically less conspicuous than the royal and official palaces, temples and tombs, and that the most important of all hydraulic works – the canals and dykes – from the standpoint of art and artistry are the least spectacular of all.

b. The monumental style

Such discrepancies notwithstanding, the palaces, government buildings, temples and tombs share one feature with the 'public' works proper: they, too, tend to be large. The architectural style of hydraulic society is monumental.

This style is apparent in the fortress-like settlements of the Pueblo Indians. It is conspicuous in the palaces, temple cities and fortresses of ancient Middle and South America. It characterizes the tombs, palace-cities, temples and royal monuments of Pharaonic Egypt and ancient Mesopotamia. No one who has ever observed the city gates and walls of a Chinese capital, such as Peking, or who has walked through the immense palace gates and squares of the Forbidden City to enter its equally immense court buildings, ancestral temples and private residences can fail to be awed by their monumental design.

Pyramids and dome-shaped tombs manifest most consistently the monumental style of hydraulic building. They achieve their aesthetic effect with a minimum of ideas and a maximum of material. The pyramid is little more than a huge pile of symmetrically arranged stones.

The property-based and increasingly individualistic society of ancient Greece loosened up the massive architecture, which had emerged in the quasihydraulic Mycenaean period.[108] During the later part of the first millennium BC, when Alexander and his successors ruled the entire Near East, the architectural concepts of Hellas transformed and refined the hydraulic style without, however, destroying its monumental quality.

In Islamic architecture the two styles blended to create a third. The products of this development were as spectacular in the western-most outpost of Islamic culture – Moorish Spain – as they were in the great eastern centres: Cairo, Baghdad, Bukhara, Samarkand and Istanbul. The Taj Mahal of Agra and kindred buildings show the same forces at work in India, a subcontinent which, before the Islamic invasion, had evolved a rich monumental architecture of its own.

c. The institutional meaning

It hardly needs to be said that other agrarian civilizations also combined architectural beauty with magnitude. But the hydraulic rulers differed from the secular and priestly lords of the ancient and medieval West, first because their constructional operations penetrated more spheres of life, and second because control over the entire country's labour power and material enabled them to attain much more monumental results.

The scattered operations of rainfall farming did not involve the establishment of national patterns of cooperation, as did hydraulic agriculture. The many manorial centres of Europe's knighthood society gave rise to as many fortified residences (castles); and their size was limited by the number of the attached serfs. The king, being little more than the most important feudal lord, had to build his castles with whatever labour force his personal domain provided.

The concentration of revenue in the regional or territorial centres of ecclesiastical authority permitted the creation of the largest individual medieval edifices: churches, abbeys and cathedrals. It may be noted that these buildings were erected by an institution which, in contrast to all other prominent Western bodies, combined feudal with quasihydraulic patterns of organization and acquisition.

With regard to social control and natural resources, however, the master builders of the hydraulic state had no equal in the nonhydraulic world. The modest Tower of London and the dispersed castles of medieval Europe express the balanced baronial society of the Magna Carta as clearly as the huge administrative cities and colossal palaces, temples and tombs of Asia, Egypt and ancient America express the organizational coordination and the mobilization potential of hydraulic economy and statecraft.[109]

F. The Bulk of All Large Nonconstructional Industrial Enterprises Managed also by The Hydraulic Government

1. A comparative view

A government capable of handling all major hydraulic and nonhydraulic construction may, if it desires, play a leading role also in the nonconstructional branches of industry. There are 'feeding' industries, such as mining, quarrying, salt gathering, etc.; and there are finishing industries, such as the manufacture of weapons, textiles, chariots, furniture, etc. Insofar as the activities in these two spheres proceeded on a large scale, they were for the most part either directly managed or monopolistically controlled by the hydraulic governments. Under the conditions of Pharaonic Egypt and Inca Peru, direct management prevailed. Under more differentiated social conditions, the government tended to leave part of mining, salt gathering, etc. to heavily taxed and carefully supervised entrepreneurs, while it continued to manage directly most of the large manufacturing workshops.

By combining these facts with what we know of the hydraulic and nonhydraulic constructional operations of the state, we may in the following table indicate the managerial position of the hydraulic state both in agriculture and industry. For purposes of comparison, we include corresponding data from two other agrarian societies and from mercantilist Europe.

Table 7.1 *Government management in the spheres of agriculture and industry*

Institutional conformations	*AGRICULTURE*		*INDUSTRY*			
	Heavy waterworks	*Farming*	*Mining, etc.*	*Construction industry*	*Manufacturing*	
					Large shops	*Small shops*
Hydraulic society	**+**	–	(+)[1]	**+**[2]	+	–
Coastal city states of classical Greece	–	–	–	–	–	–
Medieval Europe	–	(+)[3]	–	(+)[3]	(+)[3]	–
Mercantilist Europe	–	–	(–)	–	–	–

Key

+ Predominant
+ Outstandingly significant
– Irrelevant or absent
( ) Trend limited or modified by factors indicated in the text

1. Simpler conditions
2. On a national scale
3. On a manorial scale

In ancient Greece, mining was mainly in the hands of licensed businessmen. As long as the concessionaire delivered a fixed part of his output to the state, he enjoyed 'very extensive' rights; he 'was said to "buy" the mine, he organized the working as he pleased, the ore was his, and he could cede his concession to a third party'.[110] In Medieval Europe mining was also essentially left to private entrepreneurs, who, having obtained a concession from the royal or territorial authorities, proceeded independently and mostly through craft cooperatives.[111] The mercantilist governments of Europe operated some mines directly; but the majority was managed by strictly supervised private owners.[112]

All these arrangements differ profoundly from the system of government mining prevailing in Pharaonic Egypt and Inca Peru. Mercantilist usage resembles in form, but not in institutional substance, the policy pursued in certain of the more differentiated hydraulic societies, where government operation of some mines was combined with private, but government-licensed, handling of others.[113]

Except for mining, Oriental and Occidental absolutism are less similar in the industrial sphere than has been claimed, whereas a resemblance of sorts does exist between hydraulic society and feudal Europe. In hydraulic society, the majority of the not-too-many larger industrial workshops was government managed. In the mercantilist Occident they were, under varying forms of state supervision, predominantly owned and run by private entrepreneurs. In the coastal city-states of classical Greece the government was neither equipped nor inclined to engage in industrial activities. The rulers of medieval Europe, faced with a different situation, proceeded differently. In their manorial workshops they employed a number of serf-artisans, who were kept busy satisfying the needs of their masters. The feudal lords also summoned serf labour for the construction of 'big houses' – castles. The similarity between this manorial system of cooperative work and the hydraulic pattern is evident. But again the functional similarity is limited by the differences in the societal setting. The medieval kings and barons could dispose only over the labour force of their own domains and estates, while the hydraulic rulers could draw on the unskilled and skilled labour of large territories, and ultimately on that of the whole country.

The decisive difference, however, between hydraulic society and the three civilizations with which we compare it lies, insofar as industry is concerned, in the sphere of construction. It is this sphere which more than any other sector of industry demonstrates the organizational power of hydraulic society. And it is this sphere which achieved results never attained by any other agrarian or mercantilist society.

The full institutional significance of this fact becomes apparent as soon as we connect it with the corresponding agrarian development. Government-managed heavy waterworks place the large-scale feeding apparatus of agriculture in the hands of the state. Government-managed construction works make the state the undisputed master of the most comprehensive sector of large-scale industry. In the two main spheres of production the state occupied an unrivalled position of operational leadership and organizational control.

2. The power of the hydraulic state over labour greater than that of capitalist enterprises

In both spheres the hydraulic state levied and controlled the needed labour forces by coercive methods that were invocable by a feudal lord only within a restricted area, and that were altogether different from the methods customary under capitalist conditions. The hydraulic rulers were sufficiently strong to do on a national scale what a feudal sovereign or lord could accomplish only within the borders of his domain. They compelled able-bodied commoners to work for them through the agency of the corvée.

Corvée labour is forced labour. But unlike slave labour, which is demanded permanently, corvée labour is conscripted on a temporary, although recurring, basis. After the corvée service is completed, the worker is expected to go home and continue with his own business.

Thus the corvée labourer is freer than the slave. But he is less free than a wage labourer. He does not enjoy the bargaining advantages of the labour market, and this is the case even if the state gives him food (in the ancient Near East often 'bread and beer') or some cash. In areas with a highly developed money economy the hydraulic government may levy a corvée tax and hire rather than conscript the needed labour. This was done largely in China at the close of the Ming dynasty and during the greater part of Ch'ing rule.

But there as elsewhere the government arbitrarily fixed the wage. And it always kept the workers under quasimilitary discipline.[114] Except in times of open political crisis, the hydraulic state could always muster the labor forces it required; and this whether the workers were levied or hired. It has been said that the Mogul ruler Akbar, 'by his *firmān* (order) could collect any number of men he liked. There was no limit to his massing of labourers, save the number of people in his Empire.'[115] *Mutatis mutandis*, this statement is valid for all hydraulic civilizations.

G. A Genuine and Specific Type of Managerial Regime

Thus the hydraulic state fulfilled a variety of important managerial functions.[116] In most instances it maintained crucial hydraulic works, appearing in the agrarian sphere as the sole operator of large preparatory and protective enterprises. And usually it also controlled the major nonhydraulic industrial enterprises, especially large constructions. This was the case even in certain 'marginal' areas, where the hydraulic works were insignificant.

The hydraulic state differs from the modern total managerial states in that it is based on agriculture and operates only part of the country's economy. It differs from the laissez-faire states of a private-property-based industrial society in that, in its core form, it fulfils crucial economic functions by means of commandeered (forced) labour.

Notes

1 For early formulations of this view see Smith, 1937: 6; Mill, 1909: 131, 144; Marx, 1890–1894, I: 300, 322 ff. Modern economists have perpetuated and even sharpened them. Writes Seligman (1914: 350): 'In the immense domain of agricultural production the possibility of combination is almost entirely eliminated.' And Marshall (1946: 290): 'In agriculture there is not much division of labour, and there is no production on a very large scale.'

2 For the concept of 'previous or preparatory labor' see Mill, 1909: 29, 31. The general principle was already indicated by Smith (1937), who, when discussing the division of operations in industry, pointed to the 'growers of the flax and the wool' and the miners as providers of raw material (5 ff., 11), to the spinners and weavers as engaged in special processing operations (6), and to the makers of tools as combining elements of both procedures (11). Mill (1909: 36 ff.) also includes, in the category of previous labour, activities aimed at protecting industrial production proper.

3 Wittfogel, 1956: 157.

4 Wittfogel, 1931: 312, 424, 337–344. *Ibid.*, 1956: 158.

5 Buck, 1937: 61.

6 See Wittfogel, 1931: 253 ff., 261 ff., 267 ff.

7 Buckley, 1893: 10. Cf. Marshall, 1931, I: 6.

8 RRCAI: 359. Cf. Saha, 1930: 12.

9 See Strabo, 1917–1932, 16.1.10.

10 Wittfogel and Fêng, 1949: 661, n. 52.

11 Willcocks, 1904: 70.

12 See Humboldt, 1811, II: 193 ff.

13 Beech, 1911: 15.

14 Parsons, 1939, I; 111.

15 Gutmann, 1909: 20.

16 Eck and Liefrinck, 1876: 228 ff.

17 Deimel, 1928: 34. *Ibid.*, 1931: 83.

18 Sethe, 1912: 710 ff.

19 *Arthaçāstra*, 1926: 60. *Arthaçāstra*, 1923: 51 ff.

20 Blas Valeras = Garcilaso, 1945, I: 245.

21 Sahagun, 1938, I: 292, 296.

22 Ramirez, 1944: 52, 75. Tezozomoc, 1944: 381, 385.

23 Willcocks, 1889: 274.

24 *Ibid.*; 279.

25 *Ibid.*

26 Gutmann, 1926: 369, 374.

27 Parsons, 1939, I: 124–126. Wittfogel and Goldfrank, 1943: 29.

28 Rüstow, who in general accepts Kern's view concerning the correlation between large-scale and government-directed water control and the centralized and despotic character of the state in ancient Egypt and Mesopotamia, assumes that in these areas nomadic conquerors developed the hydraulic works *after* establishing conquest empires (Rüstow, 1950–1952, I: 306).
Patterns of leadership and discipline traditional to conquering groups could be, and probably were, invoked in establishing certain hydraulic governments; but Pueblo, Chagga and Hawaiian society show that such formative patterns could also be endogenous. In any case, the ethnographic and historical facts point to a multiple rather than a single origin for hydraulic societies.

29 Cf. Wittfogel, 1931: 456 ff., 680 ff. *Ibid.*, 1938: 98 ff. Wittfogel and Fêng, 1949: 123, 467.

30 Herodotus, 1942, 2.10g.

31 Anyone interested in studying the technical and organizational details of a major hydraulic order may consult Willcocks's admirable description of irrigation and flood control in 19th-century Egypt (Willcocks, 1889: *passim*). A comprehensive survey of the hydraulic conditions in India at the close of the 19th century has been made by the Indian Irrigation Commission (RRCAI). In my study of Chinese economics and society I have systematically analysed the ecological foundations and the various aspects of China's traditional hydraulic order (Wittfogel, 1931: 61–93, 188–300, and 410–456). Today we also have an archaeological account of the growth of hydraulic and other constructions over time and for a limited, but evidently, representative area: the Virú Valley in Peru (see Willey, 1953: 344–389).

32 Reed, 1937: 373. Robins, 1946: 91 ff., 129 ff.

33 For Palenque see Stevens, 1863–1877, II: 321, 344. For Aztec Mexico see Tezozomoc, 1944: 23, 379 ff.; Chimalpahin Quauhtlehuanitzin, 1889: 117, 128.

34 Cf. Pietschmann, 1889: 70.

35 Cf. Cahen, 1940: 132.

36 Jacobsen and Lloyd, 1935: 31; Luckenbill, 1926–1927, II: 150. Cf. Olmstead, 1923: 332; Thompson and Hutchinson, 1929: 129 ff.

37 See Wittfogel, 1957, ch 6.

38 Heichelheim, 1938: 728. See also Wittfogel, 1957, ch 7.

39 Williams, 1910: 168. Cf. Sombart, 1919, I: 396; II: 252.

40 Kulischer, 1928–1929, II: 381 ff.

41 Williams, 1910: 168.

42 Sombart, 1919, II: 251.

43 Williams, 1910: 168.

44 Kees, 1933: 129, cf. 109. Breasted, 1927: 147 and *passim*.

45 Thompson, 1941: 515.

46 Previously I viewed Chou China as a feudal society exhibiting Oriental features, which appeared early and became increasingly conspicuous until, at the close of the period, they prevailed completely (Wittfogel, 1931: 278 ff.; *ibid*., 1935: 40 ff.). The idea of a society that crosses the institutional divide is entirely compatible with the findings of the present inquiry; and by interpreting Chou society in this way, I would not have had to change a long-held position. But intensified comparative studies compel me to change. The arid and semi-arid settings of North China (17 inches annual rainfall in the old Chou domain and 24 inches in the domain of the pre-Chou dynasty, Shang) suggest hydraulic agriculture for the ancient core areas. The lay of the land, the summer floods, and the periodic silting-up of the rivers necessitated comprehensive measures of flood control especially in the heartland of Shang power. A realistic interpretation of legends and protohistorical sources (cf. Wittfogel and Goldfrank, 1943: *passim*) points to the rise of a hydraulic way of life long before the Shang dynasty, whose artifacts (bronzes) and inscriptions reflect a highly developed agrarian civilization with refined techniques of record keeping, calculations and astronomy. The recognizable institutions of early Chou are those of a hydraulic society, which gradually intensified its managerial and bureaucratic 'density'. The Chou sovereigns behaved toward the territorial rulers not as the first among equals but as supreme masters responsible only to Heaven. It was not their fault that their despotic claims, which possibly imitated Shang precedents, were realized imperfectly and with decreasing effect. In contrast, the rulers of the territorial states were strong enough to proceed absolutistically within their respective realms. The lands that they assigned were given not in a contractual way and to independently organized (corporated) knights and barons, but to office holders and persons permitted to enjoy sinecures. They were not fiefs but office lands.

47 See *Shih Chi*, 29.3a–b, 4b–5a, 5b–6a, 7b–8a, 126.15b. *Han Shu*, 29.2b–3a, 4a–b, 5a–b, 7a–8a, 89.14b–15a.

48 See *Shih Chi*, 29.2a–b, 4a–b. *Han Shu*, 29.1b–2a, 3b–4a, 64A.6b. *Hou Han Shu*, 35.3b.

49 *Sui Shu*, 3.11a, cf. 5a.

50 Kulischer, 1928–1929, II: 6.
51 King, 1927: 97 ff.
52 Castañeda, 1896: 512. Bandelier upholds Castañeda's figures against divergent statements made in other early Spanish sources (Bandelier, 1890&1892, I: 120 ff. and nn.; cf. *ibid.*, 1929&1930: 312, 46 ff., 171–173).
53 Castañeda, who was the official chronicler of the first Spanish expedition, notes (1896: 494) that the defence towers of a large Zuni settlement were equipped with 'embrassures and loopholes … for defending the roofs of the different stories'. He adds, 'The roofs have to be reached first, and these upper houses are the means of defending them.' The experiences of the second expedition confirmed and supplemented the initial observations. Gallegos concludes his remarks concerning Pueblo building by referring to the movable wooden ladders 'by means of which they climb to their quarters'. At night 'they lift them up since they wage war with one another' (Gallegos, 1927: 265). Obregon also stresses the military value of the ladders; in addition, he explains how the edifices themselves served to protect the community: 'These houses have walls and loopholes from which they defend themselves and attack their enemies in their battles' (Obregon, 1928: 293).
One of Coronado's lieutenants, approaching certain Tigua settlements, 'found the villages closed by palisades'. The Pueblos, whose inhabitants had been subjected to various forms of extortion and insult 'were all ready for fighting. Nothing could be done, because they would not come down onto the plain and the villages are so strong that the Spaniards could not dislodge them.' Attacking a hostile village, the Spanish soldiers reached the upper story by surprise tactics. They remained in this dangerous position for a whole day, unable to prevail until the Mexican Indians, who accompanied them, approached the Pueblo from below, digging their way in and smoking out the defenders (Castañeda, 1896: 496. For a discussion of Castañeda's report see Bandelier, 1929&1930: 38 ff.).
Besieging a large Tigua settlement, Coronado's men had an opportunity to test thoroughly the defence potential of a Pueblo which was not taken by surprise: 'As the enemy had had several days to provide themselves with stores, they threw down such quantities of rocks upon our men that many of them were laid down, and they wounded nearly a hundred with arrows.' The siege lasted for seven weeks. During this time, the Spaniards made several assaults; but they were unable to take the Pueblo. The villagers eventually abandoned their fortress-like bulwark, not because the aggressors had penetrated their defences, but because of lack of water (Castañeda, 1896: 498 ff.; cf. RDS, 1896: 576). Bandelier supplements Castañeda's report of this significant event by an account given by Mota Padilla, an 18th-century author, who claims to have had access to the original writings of still another member of Coronado's staff (Bandelier, 1929&1930: 323). Mota Padilla's version contains a number of details which reveal the techniques of attack as well as the strength and ingenuity of the defence. Some of the Spaniards 'reached the top of the wall, but there they found that the natives had removed the roofs of many (upper) rooms, so that there was no communication between them, and as there were little towers at short distances from each other, from which missiles were showered upon the assailants on the top, the Spaniards had more than 60 of their number hurt, three of whom died of their wounds' (*ibid.*, 48).
54 Castañeda (1896: 520) qualifies this general statement by saying that the women were 'engaged in making the [adobe] mixture and the walls, while the men bring the wood and put it in place'. Modern reports assign the above duties to the men and credit them in addition with erecting the walls, the construction labours of the women being confined to plastering (White, 1932: 33; cf. Parsons, 1932: 212). The divergence between the early and recent descriptions may reflect an actual institutional change or merely a difference in the accuracy of observation. While interesting to the anthropologist, this discrepancy does not affect our basic conclusions regarding the communal character of large-scale building in the American Pueblos.
55 Dundas, 1924: 73; cf. Widenmann, 1899: 63 ff.

56 Dundas, 1924: 73.
57 *Ibid.*: 95 ff.
58 *Ibid.* Cf. Widenmann, 1899: 63 ff.
59 Cortes, 1866: *passim*. Díaz, 1944: *passim*. Cf. Vaillant, 1941: 135.
60 Armillas, 1944: *passim*. Vaillant, 1941: 219.
61 Jerez, 1938: 38. Sancho de la Hos, 1938: 177 ff. Cieza, 1945: 206 ff., 245. Ondegardo, 1872: 75 ff. Garcilaso, 1945, II: 31, 146 ff. Espinosa, 1942: 565 ff. Cobo, 1890–1895, IV: 65 ff., 207 ff. Cf. Rowe, 1946: 224 ff.
62 Cobo, 1890–1895, III: 272. Garcilaso, 1945, II: 147.
63 *Arthaçāstra*, 1923: 54 ff.
64 *Shih Chi*, 88.1b.
65 Meissner, 1920–1925, I: 340.
66 *Ibid.*: 340 ff. Olmstead, 1923: 334.
67 Meissner, 1920–1925, I: 341. The term 'royal road' was used in an Assyrian inscription (Olmstead, 1923: 334). The operational pattern of the Roman state post, the *cursus publicus*, can be traced back through the Hellenistic period to Persia and perhaps even to Babylonia (Wilcken, 1912: 372 and n. 2).
68 Herodotus, 1942, 5.52 f.; 8.g8. Cf. Xenophon, 1914, 8.6.17.
69 Rostovtzeff, 1941, I: 133, 135, 173 ff., 484, 517.
70 For Diocletian's achievements in this sphere see Bury, 1931, I: 95 ff.; and Ensslin, 1939: 397.
71 Mez, 1922: 461.
72 For the Mamluks see Sauvaget, 1941: 35. For the Ottoman Turks see Taeschner, 1926: 203 ff.
73 *Arthaçāstra*, 1926: 60, and esp. 74. Strabo, 1917–1932, 15.1.50.
74 Cf. Smith, 1914: 135.
75 Appadorai, 1936, I: 424 ff.
76 Sabahuddin, 1944: 272 ff.
77 Haig, 1937: 57.
78 Smith, 1926: 413 ff.
79 *Kuo Yü*, 1935, 2.22 ff.
80 *Han Shu*, 51.2a.
81 Jerez, 1938: 55. Estete, 1938: 83 ff., 97 ff., 244 ff. Sancho de la Hos, 1938: 175. Pizarro, 1938: 259. CPLNC, 1938: 310. Cieza, 1945: *passim*. Sarmiento, 1906: 88. Ondegardo, 1872: 12. Cf. Garcilaso, 1945, II: 242 and *passim*; Cobo, 1890–1895, III: 260 ff.
82 Pizarro, 1938: 259.
83 Cieza, 1943: 95. The regional organization and the repair work on the roads had already been noted by a member of the conquering army (Estete, 1938: 246). The lack of payment for services rendered in the road corvée is also recorded by Blas Valeras, who states that similar conditions prevailed with regard to work on the bridges and irrigation canals (Garcilaso, 1945, I: 258).
84 *Chin Shih Ts'ui Pien*, 5.13a–b.
85 Widenmann, 1899: 70.
86 Ixtlilxochitl, 1891–1892, II: 174.
87 I Kings 5: 14. For ancient Mesopotamia see Schneider, 1920: 92; Mendelsohn, 1949.
88 Marshall, 1928: 587 ff.
89 *Shih Chi*, 6.31a–b.
90 *Shih Chi*, 6.13b–14a, 24a–25a.
91 See above.
92 *Sui Shu*, 3.9b.
93 Over a million in 607; an additional 200,000 persons were employed in 608 (*Sui Shu 3. 10b, 12a*).
94 *Sui Shu*, 24.16a.

95 Barton, 1929: 3 ff. Thureau-Dangin, 1907: 3 and *passim*. For epigraphic references to the temples of Babylonia and Assyria see Meissner, 1920–1925, I: 303 ff.; and Luckenbill, 1925–1927: *passim*.
96 Price, 1927: 24; cf. Thureau-Dangin, 1907: 111, and Barton, 1929: 225. Schneider (1920: 46) and Deimel (1931: 101 ff.) deplore the scarcity of concrete data concerning the Sumerian construction industry.
97 Thus in one of the oldest inscriptions of Egypt extant, the Palermo Stone (Breasted, 1927, I: 64).
98 Breasted, 1927, I: 186, 244, 336; II: 64, 72, 245, 311, 318; III: 96 ff.; IV: 116 ff., 179 ff. and *passim*.
99 'I have commanded those who work, to do according as thou shalt exact' (Breasted, 1927, I: 245). The 'people' bring the stone for the Amon Temple; and the 'people' also do the building. Among the workmen are several types of artisans (*ibid*., II: 294, 293).
100 Ramirez, 1944: 39.
101 Tezozomoc, 1944: 79 (the Temple of Huitzilopochtli) and 157 (the great Cu edifice of the same god).
102 Ixtlilxochitl, 1891–1892, II: 184.
103 Ixtlilxochitl, 1891–1892, II: 173 ff. The *Annals of Cuauhtitlan* also refer to this construction (Chimalpópoca, 1945: 52), without, however, discussing the labour aspect.
104 Chimalpópoca, 1945: 49.
105 *Ibid*.: 52.
106 Cieza, 1943: 150 ff.
107 *Ibid*.: 241. Cf. Garcilaso, 1945, I: 245, 257 ff.
108 Cf. Bengtson, 1950: 38.
109 For another peculiarity of hydraulic architecture, the 'introvert' character of most of the residential buildings, with the exception of those of the ruler, see Wittfogel, 1957: 86, n. *b*.
110 Glotz, 1926: 152, cf. 267.
111 Kulischer, 1928–1929, I: 224.
112 Sombart, 1919, II: 792. Cf. Cole, 1939, II: 458 ff.
113 Cf., for Ottoman Turkey, Anhegger, 1943: 5, 8 ff., 22 ff., 123 ff., 126 ff.
114 Boulais, 1924: 728.
115 Pant, 1930: 70.
116 Social science is indebted to James Burnham for pointing to the power potential inherent in managerial control. The present inquiry stresses the importance of the general (political) organizer as compared not only to the technical specialist (see Veblen, 1945: 441 ff.), but also to the economic manager. This, however, does not diminish the author's appreciation of the contribution made by Burnham through his concept of managerial leadership.

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8

Marcus Cato on Agriculture

Marcus Porcius Cato

It is true that to obtain money by trade is sometimes more profitable, were it not so hazardous; and likewise money-lending, if it were as honourable. Our ancestors held this view and embodied it in their laws, which required that the thief be mulcted double and the usurer fourfold; how much less desirable a citizen they considered the usurer than the thief, one may judge from this. And when they would praise a worthy man their praise took this form: 'good husbandman', 'good farmer'; one so praised was thought to have received the greatest commendation. The trader I consider to be an energetic man, and one bent on making money; but, as I said above, it is a dangerous career and one subject to disaster. On the other hand, it is from the farming class that the bravest men and the sturdiest soldiers come, their calling is most highly respected, their livelihood is most assured and is looked on with the least hostility, and those who are engaged in that pursuit are least inclined to be disaffected. And now, to come back to my subject, the above will serve as an introduction to what I have undertaken.

I. When you are thinking of acquiring a farm, keep in mind these points: that you be not over-eager in buying nor spare your pains in examining, and that you consider it not sufficient to go over it once. However often you go, a good piece of land will please you more at each visit. Notice how the neighbours keep up their places; if the district is good, they should be well kept. Go in and keep your eyes open, so that you may be able to find your way out. It should have a good climate, not subject to storms; the soil should be good, and naturally strong. If possible, it should lie at the foot of a mountain and face south; the situation should be healthful, there should be a good supply of labourers, it should be well watered, and near it there should be a flourishing town, or the sea, or a navigable stream, or a good and much travelled road. It should lie among those farms which do not often change owners; where those who have sold farms are sorry to have done so. It should be well furnished with buildings. Do not be hasty in despising the methods of management

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adopted by others.[1] It will be better to purchase from an owner who is a good farmer and a good builder. When you reach the steading, observe whether there are numerous oil presses and wine vats; if there are not, you may infer that the amount of the yield is in proportion. The farm should be one of no great equipment, but should be well situated. See that it be equipped as economically as possible, and that the land be not extravagant. Remember that a farm is like a man – however great the income, if there is extravagance but little is left. If you ask me what is the best kind of farm, I should say: a hundred iugera[2] of land, comprising all sorts of soils, and in a good situation; a vineyard comes first if it produces bountifully wine of a good quality; second, a watered garden; third, an osier-bed; fourth, an oliveyard; fifth, a meadow; sixth, grain land;[3] seventh, a wood lot; eighth, an arbustum;[4] ninth, a mast grove.[5]

II. When the master arrives at the farmstead, after paying his respects to the god of the household, let him go over the whole farm, if possible, on the same day; if not, at least on the next. When he has learned the condition of the farm, what work has been accomplished and what remains to be done, let him call in his overseer the next day and inquire of him what part of the work has been completed, what has been left undone; whether what has been finished was done betimes, and whether it is possible to complete the rest; and what was the yield of wine, grain and all other products. Having gone into this, he should make a calculation of the labourers and the time consumed. If the amount of work does not seem satisfactory, the overseer claims that he has done his best, but that the slaves have not been well, the weather has been bad, slaves have run away, he has had public work[6] to do; when he has given these and many other excuses, call the overseer back to your estimate of the work done and the hands employed. If it has been a rainy season, remind him of the work that could have been done on rainy days: scrubbing and pitching wine vats, cleaning the farmstead, shifting grain, hauling out manure, making a manure pit, cleaning seed, mending old harness and making new; and that the hands ought to have mended their smocks and hoods. Remind him, also, that on feast days old ditches might have been cleaned, road work done, brambles cut, the garden spaded, a meadow cleared, faggots bundled, thorns rooted out, spelt ground and general cleaning done. When the slaves were sick, such large rations should not have been issued. After this has been gone into calmly, give orders for the completion of what work remains; run over the cash accounts, grain accounts and purchases of fodder; run over the wine accounts, the oil accounts – what has been sold, what collected, balance due and what is left that is saleable; where security for an account should be taken, let it be taken; and let the supplies on hand be checked over. Give orders that whatever may be lacking for the current year be supplied; that what is superfluous be sold; that whatever work should be let out be let. Give directions as to what work you want done on the place, and what you want let out,[7] and leave the directions in writing. Look over the live stock and hold a sale. Sell your oil, if the price is satisfactory, and sell the surplus of your wine and grain. Sell worn-out oxen, blemished cattle, blemished sheep, wool, hides, an old wagon, old tools, an old slave, a sickly slave and whatever else is superfluous. The master should have the selling habit, not the buying habit.

III. In his youth the owner should devote his attention to planting. He should think a long time about building, but planting is a thing not to be thought about but done. When you reach the age of thirty-six you should build, if you have your land planted.[8] In building, you should see that the steading does not lag behind the farm nor the farm behind the steading. It is well for the master to have a well-built barn[9] and storage room and plenty of vats for oil and wine, so that he may hold his products for good prices; it will redound to his wealth, his self-respect and his reputation. He should have good presses, so that the work may be done thoroughly. Let the olives be pressed immediately after gathering, to prevent the oil from spoiling. Remember that high winds come every year and are apt to beat off the olives; if you gather them at once and the presses are ready, there will be no loss on account of the storm, and the oil will be greener and better. If the olives remain too long on the ground or the floor they will spoil, and the oil will be rancid. Any sort of olive will produce a good and greener oil if it is pressed betimes. For an oliveyard of 120 iugera there should be two pressing equipments, if the trees are vigorous, thickly planted and well cultivated. The mills should be stout and of different sizes, so that if the stones become worn you may change. Each should have its own leather ropes, six sets of hand bars, six double sets of pins and leather belts. Greek blocks run on double ropes of Spanish broom; you can work more rapidly with eight pulleys above, and six below; if you wish to use wheels it will work more slowly but with less effort.

IV. Have good stalls, stout pens and latticed feed-racks. The rack bars should be a foot apart; if you make them in this way the cattle will not scatter their feed. Build your dwelling-house in accordance with your means. If you build substantially on a good farm, placing the house in a good situation, so that you can live comfortably in the country, you will like to visit it, and will do so oftener; the farm will improve, there will be less wrongdoing, and you will receive greater returns; the forehead is better than the hindhead.[10] Be a good neighbour, and do not let your people commit offences. If you are popular in the neighbourhood it will be easier for you to sell your produce, easier to let out your work,[11] easier to secure extra hands. If you build, the neighbours will help you with their work, their teams, and their materials; if trouble comes upon you, which God forbid,[12] they will be glad to stand by you.

V. The following are the duties of the overseer: He must show good management. The feast days must be observed. He must withhold his hands from another's goods and diligently preserve his own. He must settle disputes among the slaves; and if anyone commits an offence he must punish him properly in proportion to the fault. He must see that the servants are well provided for, and that they do not suffer from cold or hunger. Let him keep them busy with their work – he will more easily keep them from wrongdoing and meddling. If the overseer sets his face against wrongdoing, they will not do it; if he allows it, the master must not let him go unpunished. He must express his appreciation of good work, so that others may take pleasure in well-doing. The overseer must not be a gadabout, he must always be sober, and must not go out to dine. He must keep the servants busy, and see that the master's orders are carried out.

He must not assume that he knows more than the master. He must consider the master's friends his own friends. He must pay heed to anyone to whom he has been bidden to listen. He must perform no religious rites, except on the occasion of the Compitalia[13] at the cross-roads, or before the hearth. He must extend credit to no one without orders from the master, and must collect the loans made by the master. He must lend to no one seed-grain, fodder, spelt, wine or oil. He must have two or three households, no more, from whom he borrows and to whom he lends. He must make up accounts with the master often. He must not hire the same day-labourer or servant or caretaker for longer than a day. He must not want to make any purchases without the knowledge of the master, nor want to keep anything hidden from the master. He must have no hanger-on. He must not consult a fortune-teller, or prophet or diviner or astrologer.[14] He must not stint the seed for sowing, for that brings bad fortune. He must see to it that he knows how to perform all the operations of the farm, and actually does perform them often, but not to the extent of becoming exhausted; by so doing he will learn what is in his servants' minds, and they will perform their work more contentedly. Also, he will be less disposed to gad about, will be in better health, and will enjoy his sleep more. He must be the first out of bed, the last to go to bed. Before then he must see that the farmstead is closed, that each one is asleep in his proper place, and that the stock have fodder.

See that the draft oxen are looked after with the greatest care, and be somewhat indulgent to the teamsters to make them look after their stock with more pleasure. See that you keep your ploughs and ploughshares in good condition. Be careful not to plough land which is *cariosa*[15] or drive a cart over it, or turn cattle into it; if you are not careful about this, you will lose three years' crop of the land on which you have turned them. Litter the cattle and flocks carefully, and see that their hoofs are kept clean. Guard against the scab in flocks and herds; it is usually caused by under-feeding and exposure to wet weather. See that you carry out all farm operations betimes, for this is the way with farming: if you are late in doing one thing you will be late in doing everything. If bedding runs short, gather oak leaves and use them for bedding down sheep and cattle. See that you have a large dunghill; save the manure carefully, and when you carry it out, clean it of foreign matter and break it up. Autumn is the time to haul it out. During the autumn also dig trenches around the olive trees and manure them. Cut poplar, elm and oak leaves betimes; store them before they are entirely dry, as fodder for sheep. Second-crop hay and aftermath should also be stored dry. Sow turnips, forage crops and lupins after the autumn rains.

VI. This rule should be observed as to what you should plant in what places: Grain should be sown in heavy, rich, treeless soil; and if this sort of soil is subject to fogs it should preferably be sown with rape, turnips, millet and panic-grass. In heavy, warm soil plant olives[16] – those for pickling, the long variety, the Sallentine, the orcites, the posea, the Sergian, the Colminian and the waxy-white; choose especially the varieties which are commonly agreed to be the best for these districts. Plant this variety of olives at intervals of 25 or 30 feet. Land which is suitable for olive planting is that which faces the west and is exposed to the sun; no other will be good. Plant the Licinian olive in colder and thinner soil. If you plant it in heavy or warm soil the yield will be worthless, the tree will exhaust itself in bearing, and a reddish scale will injure it. Around the borders of the farm and along the roads plant elms and some poplars, so that you may have leaves for the sheep and cattle; and the timber will be available if you need it. Wherever there is a river bank or wet ground, plant poplar cuttings and a reed thicket. The method of planting is as follows: turn the ground with the mattock and then plant the eyes of the reed three feet apart. Plant there also the wild asparagus,[17] so that it may produce asparagus; for a reed thicket goes well with the wild asparagus, because it is worked and burned over, and furnishes a shade when shade is needed. Plant Greek willows along the border of the thicket, so that you may have withes for tying up vines.

Choose soil for laying out a vineyard by the following rules: In soil which is thought to be best adapted for grapes and which is exposed to the sun, plant the small Aminnian,[18] the double eugeneum and the small parti-coloured; in soil that is heavy or more subject to fogs plant the large Aminnian, the Murgentian, the Apician and the Lucanian. The other varieties, and especially the hybrids, grow well anywhere.

VII. It is especially desirable to have a plantation[19] on a suburban farm, so that firewood and faggots may be sold, and also may be furnished for the master's use. On the same farm should be planted anything adapted to the soil, and several varieties of grapes, such as the small and large Aminnian and the Apician. Grapes are preserved in grape-pulp in jars;[20] also they keep well in boiled wine, or must, or after-wine.[21] You may hang up the hard-berried and the larger Aminnian and they will keep as well dried before the forge fire as when spread in the sun. Plant or ingraft all kinds of fruit – sparrow-apples, Scantian and Quirinian quinces,[22] also other varieties for preserving, must-apples and pomegranates (the urine or dung of swine should be applied around the roots of these to serve as food for the fruit); of pears, the volema, the Anician frost-pears (these are excellent when preserved in boiled wine),[23] the Tarentine, the must-pear, the gourd-pear and as many other varieties as possible; of olives, the orcite and posea, which are excellent when preserved green in brine or bruised in mastic[24] oil. When the orcites are black and dry, powder them with salt for five days; then shake off the salt, and spread them in the sun for two days, or pack them in boiled must without salt. Preserve sorbs in boiled must; or you may dry them; make them quite free from moisture. Preserve pears in the same way.

VIII. Plant mariscan figs in chalky, open soil; the African, Herculanean, Saguntine, the winter variety, the black Tellanian with long pedicles, in soil which is richer or manured. Lay down a meadow, so that you may have a supply of hay – a water meadow if you have it, if not, a dry meadow. Near a town it is well to have a garden planted with all manner of vegetables, and all manner of flowers for garlands – Megarian bulbs, conjugulan myrtle,[25] white and black myrtle, Delphian, Cyprian, and wild laurel, smooth nuts, such as Abellan, Praenestine and Greek filberts. The suburban farm, and especially if it be the only one, should be laid out and planted as ingeniously as possible.

Marcus Terentius Varro on Agriculture

Marcus Terentius Varro

Book I

1. Had I possessed the leisure, Fundania,[1] I should write in a more serviceable form what now I must set forth as I can, reflecting that I must hasten; for if man is a bubble, as the proverb has it, all the more so is an old man. For my 80th year admonishes me to gather up my pack before I set forth from life. Wherefore, since you have bought an estate and wish to make it profitable by good cultivation, and ask that I concern myself with the matter, I will make the attempt; and in such wise as to advise you with regard to the proper practice not only while I live but even after my death. And I cannot allow the Sibyl to have uttered prophecies which benefited mankind not only while she lived, but even after she had passed away, and that too people whom she never knew – for so many years later we are wont officially to consult her books when we desire to know what we should do after some portent – and not do something, even while I am alive, to help my friends and kinsfolk. Therefore I shall write for you three handbooks to which you may turn whenever you wish to know, in a given case, how you ought to proceed in farming. And since, as we are told, the gods help those who call upon them, I will first invoke them – not the Muses, as Homer and Ennius do, but the 12 councillor-gods;[2] and I do not mean those urban gods, whose images stand around the forum, bedecked with gold, six male and a like number female, but those 12 gods who are the special patrons of husbandmen. First, then, I invoke Jupiter and Tellus, who, by means of the sky and the earth, embrace all the fruits of agriculture; and hence, as we are told that they are the universal parents, Jupiter is called 'the Father', and Tellus is called 'Mother Earth'. And second, Sol and Luna, whose courses are watched in all matters of planting and harvesting. Third, Ceres and Liber, because their fruits are most necessary for life; for it is by their favour that food and drink come from the farm. Fourth, Robigus and Flora; for when they are propitious the rust will not harm the grain and the trees, and they will not fail to bloom in their season; wherefore, in honour of Robigus has been established the solemn feast of the Robigalia, and in honour of Flora the games called Floralia. Likewise I beseech Minerva and Venus, of whom the one protects the oliveyard

and the other the garden; and in her honour the rustic Vinalia has been established.[3] And I shall not fail to pray also to Lympha and Bonus Eventus, since without moisture all tilling of the ground is parched and barren, and without success and 'good issue' it is not tillage but vexation. Having now duly invoked these divinities, I shall relate the conversations which we had recently about agriculture, from which you may learn what you ought to do; and if matters in which you are interested are not treated, I shall indicate the writers, both Greek and Roman, from whom you may learn them.

III. 'Well, then', said Agrasius, 'since we have decided the nature of the subjects which are to be excluded from agriculture, tell us whether the knowledge of those things used in agriculture is an art or not, and trace its course from starting-point to goal.' Glancing at Scrofa, Stolo said: 'You are our superior in age, in position, and in knowledge, so you ought to speak.' And he, nothing loath, began: 'In the first place, it is not only an art but an important and noble art. It is, as well, a science, which teaches what crops are to be planted in each kind of soil, and what operations are to be carried on, in order that the land may regularly produce the largest crops.

IV. 'Its elements are the same as those which Ennius says are the elements of the universe – water, earth, air and fire.[4] You should have some knowledge of these before you cast your seed, which is the first step in all production.[5] Equipped with this knowledge, the farmer should aim at two goals, profit and pleasure; the object of the first is material return, and of the second enjoyment. The profitable plays a more important role than the pleasurable; and yet for the most part the methods of cultivation which improve the aspect of the land, such as the planting of fruit and olive trees in rows, make it not only more profitable but also more saleable, and add to the value of the estate. For any man would rather pay more for a piece of land which is attractive than for one of the same value which, though profitable, is unsightly. Further, land which is more wholesome is more valuable, because on it the profit is certain; while, on the other hand, on land that is unwholesome, however rich it may be, misfortune does not permit the farmer to reap a profit. For where the reckoning is with death, not only is the profit uncertain, but also the life of the farmers; so that, lacking wholesomeness, agriculture becomes nothing else than a game of chance, in which the life and the property of the owner are at stake. And yet this risk can be lessened by science; for, granting that healthfulness, being a product of climate and soil, is not in our power but in that of nature, still it depends greatly on us, because we can, by care, lessen the evil effects. For if the farm is unwholesome on account of the nature of the land or the water, from the miasma which is exhaled in some spots; or if, on account of the climate, the land is too hot or the wind is not salubrious, these faults can be alleviated by the science and the outlay of the owner. The situation of the buildings, their size, the exposure of the galleries, the doors and the windows, are matters of the highest importance. Did not that famous physician, Hippocrates, during a great pestilence save not one farm but many cities by his skill?[6] But why do I cite him? Did not our friend Varro here, when the army and fleet were at Corcyra, and all the houses were crowded with the sick and the dead, by cutting new windows to admit the north wind, and shutting out the infected winds, by changing the position of doors, and other precautions of the same kind, bring back his comrades and his servants in good health?[7]

V. 'But as I have stated the origin and the limits of the science, it remains to determine the number of its divisions.' 'Really,' said Agrius, 'it seems to me that they are endless, when I read the many books of Theophrastus, those which are entitled "The History of Plants" and "The Causes of Vegetation".' 'His books,' replied Stolo, 'are not so well adapted to those who wish to tend land as to those who wish to attend the schools of the philosophers;[8] which is not to say that they do not contain matter which is both profitable and of general interest. So, then, do you rather explain to us the divisions of the subject.' 'The chief divisions of agriculture are four in number,' resumed Scrofa: 'First, a knowledge of the farm, comprising the nature of the soil and its constituents; second, the equipment needed for the operation of the farm in question; third, the operations to be carried out on the place in the way of tilling; and fourth, the proper season for each of these operations. Each of these four general divisions is divided into at least two subdivisions: the first comprises questions with regard to the soil as such, and those which pertain to housing and stabling. The second division, comprising the movable equipment which is needed for the cultivation of the farm, is also subdivided into two: the persons who are to do the farming, and the other equipment. The third, which covers operations, is subdivided: the plans to be made for each operation, and where each is to be carried on. The fourth, covering the seasons, is subdivided: those which are determined by the annual revolution of the sun, and those determined by the monthly revolution of the moon. I shall discuss first the four chief divisions, and then the eight subdivisions in more detail.

VI. 'First, then, with respect to the soil of the farm, four points must be considered: the conformation of the land, the quality of the soil, its extent, and in what way it is naturally protected. As there are two kinds of conformation, the natural and that which is added by cultivation, in the former case one piece of land being naturally good, another naturally bad, and in the latter case one being well tilled, another badly, I shall discuss first the natural conformation. There are, then, with respect to the topography, three simple types of land – plain, hill and mountain; though there is a fourth type consisting of a combination of these, as, for instance, on a farm which may contain two or three of those named, as may be seen in many places. Of these three simple types, undoubtedly a different system is applicable to the lowlands than to the mountains, because the former are hotter than the latter; and the same is true of hillsides, because they are more temperate than either the plains or the mountains. These qualities are more apparent in broad stretches, when they are uniform; thus the heat is greater where there are broad plains, and hence in Apulia the climate is hotter and more humid, while in mountain regions, as on Vesuvius, the air is lighter and therefore more wholesome. Those who live in the lowlands suffer more in summer; those who live in the uplands suffer more in winter; the same crops are planted earlier in the spring in the lowlands than in the uplands, and are harvested earlier, while both sowing and reaping come later in the uplands. Certain trees, such as the fir and the pine, flourish best and are sturdiest in the mountains on account of the cold climate, while the poplar and the willow thrive here where the climate is warmer; the arbute and the oak do better in the uplands, the almond and the mariscan fig in the lowlands. On the foothills the growth is nearer akin to that of the plains than to that of the mountains; on the higher hills the opposite is true. Owing to these three types of configuration different crops are planted, grain being considered best adapted to the plains, vines to the hills, and forests to the mountains. Usually the winter is better for those who live in the plains, because at that season the pastures are fresh, and pruning can be carried on in more comfort. On the other hand, the summer is better in the mountains, because there is abundant forage at that time, whereas it is dry in the plains, and the cultivation of the trees is more convenient because of the cooler air. A lowland farm that everywhere slopes regularly in one direction is better than one that is perfectly level, because the latter, having no outlet for the water, tends to become marshy. Even more unfavourable is one that is irregular, because pools are liable to form in the depressions. These points and the like have their differing importance for the cultivation of the three types of configuration.'

Notes

Marcus Cato on Agriculture

1 Others render, 'Be careful not rashly to refuse to learn from others.'

2 A iugerum is approximately two-thirds of an acre.

3 It is most significant that Cato places grain farming sixth in importance. The second Punic War had completely demoralized the Republic. The yeomanry had been conscripted and the fields desolated and burned. 'Roman farmers torn from their homes for years and demoralized by the camps were unable or unwilling to settle down into the quiet routine of agricultural life… Their farms passed into the hands of capitalists, and the rich lands of Italy fell back into pasture, and half-naked slaves tended herds of cattle' (Bosworth Smith, *Rome and Carthage*, p230). Grain farming was no longer profitable, and it had become the custom to import grain from Sicily and Africa. The new Rome that emerged from this horrible war centred around a nobility of wealth and was in a state of demoralization. Such a condition naturally caused the cultivation of grain to be less important than that of the vine, the olive, domestic vegetables or the rearing of cattle.

4 The word is used of a plantation of trees, to which the vines were 'wedded' or of an orchard. Columella gives a description, Book V, Chapter 6, but Cato seems not to use the word in the sense first given.

5 To furnish feed for livestock.

6 Possibly on the public roads, as in the French corvée.

7 It was the regular custom among the Romans to let out certain work by contract in contrast with the work that was done by the farm organization under the management of the overseer.

8 The 'planting' is, of course, of trees and vines.

9 See Columella, I, 6; but Cato's villa had only two units, the *villa urbana*, or dwelling-house, and the *villa rustica*, for all other purposes.

10 The content of this homely maxim appears in practically all the writers on agriculture, and has entered, in some form, into almost all proverbial wisdom. Perhaps its most popular modern form is taken from Poor Richard'a almanack: 'The eye of a master will do more work than both his hands.' Cf Columella, I, 1, 18; Pliny, N. H., XVIII, 31.

11 See note 7.

12 *bona salute* is merely a formula to avoid the evil omen of mentioning misfortune.

13 The festival held annually at the cross-roads, in honour of the Lares Compitales. It occurred soon after the Saturnalia, in December, on a day, or days appointed by the praetor.

14 Compare Horace's warning against 'meddling with Babylonian calculations' (*Odes*, I, II), and many others. Columella, I, 8, 6, emphasizes the warning.

15 The term is explained by Columella, II, 4, 5: 'that is, when after a long, dry spell, a light rain wets the surface but does not sink in.' The injunction is repeated there.

16 For a description of the various varieties of olives, see Columella, V, 8. The Romans were experts in plant selection, and developed distinct varieties of all the leading horticultural and field crops.

17 *Corruda*: identified in the 5th (?) cent. Herbal under the name of Pseudo-Apuleius (*Herb*., 84) as 'the wild asparagus which the Greeks call ορμινον or μνακανδον and by other names.'

18 See Columella, III, 2 for a detailed discussion of varieties of grapes. In Chapter 9 he returns to the discussion of the Aminnian, and remarks that these were 'almost the only varieties known to the ancients'.

19 Cf note 4.

20 Cf Varro, I, 54, 2.

21 A small or sharp wine made from the husks of grapes; cf Varro, I, 54, 3.

22 Cf Varro, I, 59, 1.

23 Cf Varro, I, 59, 3.

24 This resin from the mastic-tree is used also to flavour a distilled liquor used in various countries, as Turkey, Greece, etc.

25 Pliny says (XV, 122) that the name is perhaps derived from that for marriage (*coniugium*). The colours are those of the berries.

Marcus Terentius Varro on agriculture

1 Varro's wife.

2 In the Etrusco-Romish language of religion, the twelve superior deities who formed the common council of the gods, assembled by Jupiter. The word occurs only in this phrase. Their names are given by Ennius in the hexameters:

Juno, Vesta, Minerva, Ceres, Diana, Venus, Mars, Mercurius, Ioui', Neptunus, Vulcanus, Apollo.

3 The festival occurred on 19 August; and Varro tells us (*De Ling. Lat.*, VI, 16) that it was 'because at that time a temple was dedicated to Venus, and the protection of the garden is assigned to her'. But Ovid, *Fasti*, IV, 877f offers another explanation.

4 Ennius, *Epicharmus*, frag. III, aqua, terra, anima, sol.

5 *Quod initium fructuum oritur* is variously interpreted. The present editors believe that quod must refer to the nominal idea *iacere semina* derived from the preceding clause.

6 The incident is mentioned by Pliny, *N.H.*, VII, 123.

7 Pompey's forces lay at Corcyra before Pharsalia, and Varro had joined him after surrendering to Caesar in Spain.

8 It will be understood that the word covers the meaning of our 'scientist'.

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9

Agroecological Farming Systems in China

Li Wenhua

The Philosophy and Technology Related to IFS in Ancient China

Though the term integrated farming system (IFS) has been formally used for no more than 30 years, some primitive philosophy and technologies for implementation of this system can be traced back to ancient times (Tang, 1988; Tang, 1990; Li, 1993; Zhang et al, 1996).

Influence of ancient philosophical ideas on development of IFS

For thousands of years, Chinese philosophers have pondered on the harmonious relationship between humans, nature and the environment. The *Tian Ren He Yi* theory (heaven/nature and human/society are merged into one unit) had great influence among Chinese people and formed the roots of China's IFS. The most vigorous and flourishing development of the integrated concept was in the Spring and Autumn to Warring States period (720–221 BC). A set of systematic principles for the management of the relationships between man and the environment was formulated. For example, in a famous treatise, *Zhou Yi* (The Book of Change), a brief but deeply philosophical concept of the holistic relationship between *Tian* (heaven or nature), *Di* (earth or resources) and *Ren* (humans or society) was described. Respect for *Dao-Li* (natural relationship with the universe, geography, climate, etc.), *Shi-Li* (planning and management of human activities, such as agriculture, warfare, politics, family and others), and *Qing-Li* (ecological ethics, psychology, motives and values towards the environment) became a general principle for managing all social and productive matters. The *Yin* and *Yang* theory (negative and positive forces interacting with each other and ecological relationships) and the *Wuxing* theory (five elements within a system and the interrelated movements between them) have been widely used in agriculture to reflect the relationship between different components.

In ancient China, the people have long used the terms of *Xiang Cheng* and *Xiang Ke* to express the positive and negative relationships between different components when they co-exist. Two or more of these can integrate to exert *Xi ang Cheng* for their mutual benefits, and to use *Xiang Ke* for living control. All these basic philosophical concepts have profound influence on the practice and formulation of IFS (Wang, 1996).

The beginnings of IFS in ancient China

In the course of China's long history of agriculture, a wealth of knowledge and theories have accumulated (Institute of the History of Natural Sciences, 1985; Guo et al, 1986; Tang, 1986; Liang, 1989). Archaeological evidence has revealed that the ancestors of the Chinese people inhabited forests where they sheltered from external hazards and lived on edible parts of wild plants and animals. In the New Stone Age (6000–8000 BC), the Chinese initiated fire farming in which forests were burned and seeds were directly sown in soil covered with the ash. Tillage farming arose later on the burned land and the ash was mixed with soil before planting. Grains or other crops were grown without external fertilizer. After several years the crop yield decreased remarkably, and cultivation would shift to another forest and the same practices were repeated. Such slash-and-burn cultivation is the oldest and most primitive form of ecoagriculture and was widely practised over a period of 6000–7000 years until the Xia Dynasty (2000–1600 BC) when there was a gradual shift to settled farming, except in some remote mountainous areas in south-western China and among some minorities such as the Du Long, Nu, Xi Wa and Yao.

Slash-and-burn was also widely used in silviculture, for reforestation and afforestation with Chinese fir (*Cunninghamia laceolata*) in southern China, for thousands of years. Farmers remove all ground cover, including small trees and shrubs in summer, burn them in autumn, level the ground to mix in the ashes in winter and then either plant seedlings or cuttings of fir trees with other crops in spring, or grow crops for one or two years before tree planting. In newly established fir stands, intercropping is also practised until crown closure. Such measures, used in the process of establishment of fir forests, are similar to the Taungya system developed for management of teak (*Tectona grandis*) stands in Myanmar in the mid-1800s. Interplanting of trees and crops, now known as agroforestry, originated in the Shang-West Zhou Dynasties (1600–800 BC), as the forested land of the plains was converted into cultivated land, and farmers planted trees in or around the crop fields. Some grew fruit trees, vegetables or bred domestic animals (Gui Mowen, 1990), whereas in the mountainous areas with fewer people and more forests, peasants cultivated cash crops in the forests or interplanted food crops during reforestation and afforestation. Since then, various forms of agroforestry–animal husbandry have been developed and improved with appropriate facilities and structures in accordance with local conditions, particularly in the Ming and Qing Dynasties (14th–19th centuries) (Liang, 1983).

According to historical records, in the latter part of the New Stone Age (2500–2100 BC), along with an increase in population, collapse of the clan society and the appearance of slavery, agriculture developed rapidly. Slash-and-burn was no longer the main farming system except in less-populated but abundantly forested and underdeveloped areas. Instead of nomadic farming, the slave owners allotted a portion of their land to each slave. The slaves no longer moved to forested land for cultivation but settled in one place where they engaged in farming permanently. The forests on hilly land were preserved as pasture or hunting sites. Settled farming in the Xia and Shang Dynasties (2000–1100 BC) became a force pushing agricultural development. By that time, people began to make and improve bronze and wooden agricultural tools; to use animal labour in farming; to grow different crops, such as rice, wheat, millet, sorghum and beans; to raise domestic animals such as horses, cattle, sheep, chickens, pigs; and to cultivate fruit trees, vegetables, mulberry trees (*Morus alba*) and flax. Thus appeared the embryonic form of management of multi-component farming which included agriculture, silviculture, animal husbandry and sericulture and laid the foundation for small self-sufficient household economy.

During the West Zhou Dynasty (1100–700 BC), the slavery system gradually collapsed, and a land tenancy system, the 'nine squares', was widely adopted, particularly in the northern China Plain, as described by Mensius (400 BC). Under this system, a large portion of land was divided into nine equal square areas, of which the eight on the edges were allotted to serfs, while the central one belonged to the landlord and was managed by the eight serfs for him. Thus private land ownership was gradually established and resulted in further development of self-sufficient small farmers in which the family was the production unit. In this unit, agriculture, animal husbandry, silviculture, sericulture and domestic handicrafts were developed simultaneously and formed the so-called 'man-farming, woman-weaving' rural economy. This scenario was recorded in the *Book of Songs* (800 BC): 'trespass not on my lane, break not my willow trees; leap not over my fence, pick not my mulberry leaves; intrude not into my garden, cut not my sandwood trees' (Li, 1993).

Agricultural policy during these periods advocated and encouraged comprehensive production for multiple purposes as an effective way to prosperity. Mensius (400 BC), in praise of the self-sufficient small farming economy, emphasized 'if a family owns a certain piece of land with mulberry trees around its house for breeding silkworms, domesticated animals raised in its yard for meat, and crop fields cultivated and managed properly for cereals, it will be prosperous and will not suffer from starvation' (Tang, 1986). He also said that 'If the forests are timely felled, then an abundant supply of timber and firewood is ensured, if the fishing net with relatively big holes is timely cast into the pond, then there will be no shortage of fish and turtle for use' (Zhang, 1992). These present a picture of a prosperous, diversified rural economy and a vivid sketch of pastoral peace.

In the Spring–Autumn (770–481 BC) and Warring States (490–220 BC) Dynasties, a more sophisticated system of integrated farming developed. In the *Guan* Zi, written in the Warring States period, it was recorded that 'food will be plentiful, if five kinds of cereal crops were planted, the people would be satisfied if animals were raised, and the farmers would be enriched if mulberry and economic crops were planted'. This multi-planting system with effective use of time was reported in the *Xun* Zi published in the Warring States period. Many examples were recorded which showed the order in time of multi-harvest plantation.

Thoughts and practices from the Qin to the Tang Dynasty

History next witnessed the unification and fall of the Qin Dynasty (221–207 BC) and the decades of warring between Chu and Han States (210–105 BC). We are lucky to be able to find a number of systematic agriculture treatises from that time. Some contain valuable ideas and primitive concepts of ecological agriculture. Among the extant comprehensive works on agriculture, the four essays in *Lu Shi Chun Qiu* (Master Lu's Spring and Autumn Annals), namely, *Shen Nong* (Lay Stress on Agriculture), *Ren Di* (Capacity of Soil), *Bian Tu* (Work on Ground) and *Shen Shi* (Fitness of the Season) completed in 239 BC, can be claimed as the earliest agricultural treatises. *Lu Shi Chun Qiu* was written collectively by scholars who were guests at the house of Lu Buwei, the first prime minister of Qin. The above-mentioned essays are not independent specialized writings on agriculture, but together form a systematic and complete set of treatises. If *Shen Nong* deals mainly with the importance of promoting agricultural production at a political level, emphasizing agriculture as the root and industry and commerce as the branches, then the three essays *Ren Di*, *Bian Tu* and *Shen Shi* were devoted solely to agronomy. The three sum up the experiences of agricultural production of the labouring people before the Qin Dynasty and include a series of profound ideas and techniques for promoting productivity and conservation of natural resources and the environment.

At the beginning of the Han Dynasty, society became stable and the population grew steadily to 40 million. Experience accumulated from the past was collated, revised and much extended to serve as a guideline for agricultural policy making. In the Western Han Dynasty (206 BC–AD 24), *Fan Sheng Zhi Shu* (The Book of Fan Shengzhi) sums up the basic principles of farming in northern China. It gives an accurate description of the cultivation techniques, of the main crops and cash tree species, such as spiked millet, glutinous millet, winter wheat, spring wheat, rice, lesser beans and soya, female hemp, common perilla, male hemp, melon, gourd, taro and mulberry. The so-called *San Yi* principle was formulated by that time, as stated in *Huai Nan Zi* (The Book of Huai Nan Zi, about 100 BC). Since ancient times, those who want to become masters of the people were exorted to make the best use of time and land plus human labour for production. Consequently, crops flourished, domestic animals thrived, trees were timely planted, and fields were regularly worked. Mulberry trees and hemp were grown on fertile soil, while on hilly and steep mountain slopes unsuitable for crop growing, trees were planted for timber and firewood.

Therefore, each site was used for appropriate production and 'to fish where water is rich, to forest where mountain is dominant, to raise livestock where forage is abundant, to plant crops where land is arable', and to guide year-round activities with 24 solar subseasons in order to synchronize these activities with the climate. Such timely and well arranged multi-component activities resulted in enormous economic benefits. (Institute of the History of Natural Sciences, 1985).

Among the Chinese classics, *Qi Min Yao Shu* (Essential Farming Skills of the People of Qi), written by Jia Sixie some 1400 years ago, is the best preserved and most comprehensive. Jia Sixie's attitude towards writing *Qi Min Yao Shu* was very serious. According to his own account, he gathered a large amount of data from classic and contemporary writings, collected many proverbs and folksongs, made inquiries from experts and drew from personal experience. The book embraces farming, forestry, animal husbandry, sideline production and fishery in an area comprising today's southeastern Shanxi, central–south Hebei, part of Henan, north of the Huanghe (Yellow) River, and Shandong. Consisting of 110,000 words, the book covered a wide range of knowledge of agriculture including detailed description of rotation and intercropping systems, as well as a wealth of useful knowledge on the improvement of soil fertility and soil and water conservation. In accordance with the characteristics of crops, he distinguished those that could be rotted from those that could not. He also provided a set of rotation methods and pointed out that plants of the bean family were the best forerunner crops for improving soil fertility. He remarked that 'For spiked millet, it is best to sow in soils following mung bean or lesser bean, or to sow panicled millet or sesame in soil following hemp, and least successful to sow in soil that has been planted to turnip.' The Chinese labouring people have rich experience in breeding varieties of crops/vegetables for a fixed cultivation system. The term 'garden-style cultivation' or 'gardenization' is sometimes used to describe this multi-component system. The *Qi Min Yao Shu* mentioned that mallow (*Malva verticillata*, called *kui* in ancient China) can be sown three times and that chives were harvested not more than five times a year, indicating that the vegetation was sown and harvested continually on one piece of land. Sowing coriander and scallion or lesser beans among melon-vines and growing coriander and green onion together suggests that interplanting was practised in the cultivation of vegetables at that time (Fan Chuyu, 1984).

Qi Min Yao Shu also provides, in its 'Miscellany', notes on growing a large variety of vegetables: near the cities and towns, more melons, fruits and eggplants should be grown, as what is not consumed by the family can easily be sold. If there are 10*mu* (1*mu* equals 1/15ha or roughly 1/6 acre) of land, pick out the five that are most fertile. Use 2.5*mu* to grow green onion and the other half to sow sundry vegetables like gourds, radish, mallow, lettuce, turnip, white pea, lesser bean and eggplant in the second, fourth, sixth, seventh and eighth month, respectively (Dong Kaichen, 1984). The chapter *Zhong Sang Zhe* (Mulberry Cultivation) in *Qi Min Yao Shu* described the experience of intercropping mulberry with bean and other crops. The seedlings of mulberry tree were first grown in a nursery 5 feet apart and then replanted 10*bu* apart (approximately 7–8m). If beans and appropriate crops are cultivated between mulberry, the space can be fully utilized, while the fertility of the soil can be improved. However, the intercropping of mulberry with maize and sorgum or millet will be harmful to the soil. Radish can be grown within 60cm of the trees. When the radish are harvested, pigs can be put in to feed on the residues of crops and to loosen the soil. Jia Sixie affirmed the role of green manure in soil improvement, and suggested that the best way is to plough in mung beans, then lesser beans and sesame. In brief, *Qi Min Yao Shu* is not only rich in content, it is detailed and accurate. It sums up the vast amount of agricultural knowledge accumulated in China before the 6th century, with a deep understanding of the interrelationship between crops and their environment and implementation of the knowledge in agricultural practice.

China is the country which first raised silkworms, planted mulberry trees and wove the wonderful silk fabric. Silk culture existed in China 4000 years ago, the embryo of IFS had appeared in the Shang–Zhou period (1600–1100 BC), and records of the Han Dynasty (206 BC– AD 220) mention sericulture in the *Can Shu* (Books on Silkworm Raising) and *Zhong Shu Cang Guo Xiang Can* (How to Plant Trees, Store Fruits and Judge Silkworm). Unfortunately, none of these has come down to us. In the more than 2000 years since the Han Dynasty, however, a number of ancient books discussing sericulture have been handed down. Some are monographs; others devote chapters to sericulture. In the techniques of sericulture, not only the integration of mulberry cultivation with silkworm raising was included, but the methods of cultivation of different types of mulberry in cooperation with other plants. For instance, *Fan Sheng Zhi Shu* tells how to grow mulberry trees: 'In the first year, sow a mixture of mulberry seeds and glutinous millet. When the mulberry plants are as high as the millet, cut them down with a sickle close to the ground. Next spring mulberry suckers will spring out. Such mulberry trees are convenient for plucking and management because of their shortness.' Through continuous efforts and improvement by farmers in different periods, sericulture, together with animal husbandry or fishery, has become the major 'sideline' production in the self-sufficient rural economy. Handicraft industries, including silk reeling, spinning and weaving, also rapidly developed. Around 200 BC silk from China made its way to middle and western Asia and Europe along a route that became known as the Silk Road (Institute of the History of Natural Sciences, 1985). In the *Nong Sang Tong Jue* (Handbook for Farming and Mulberry) it is said that 'among the nine prefectures, each field is different in its landscape, water condition and climate. Different crop varieties are suitable for different fields.' It was recorded in the *Xia Zhou Shu* that 'The following is law: To cut the trees on the mountain in spring is forbidden, fishing is forbidden in water areas during summer.' This was the first law for the protection of natural resources. In the *Huainan Tzi*, it was also pointed out that 'Those pregnant cannot be killed; those in egg stage cannot be fetched; fish shorter than 12 inches cannot be caught; pigs younger than one year should not be eaten.'

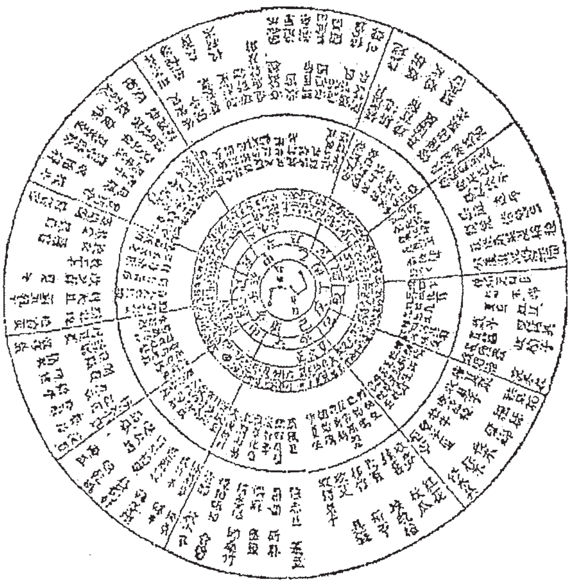
Thoughts and practices from the Tang to the Yuan Dynasty

A well-known paper on comprehensive agriculture, *Chen Fu Nong Shu* (Agricultural Treatise of Chen Fu), was completed in 1149 in the Southern Song Dynasty (1127–1179). In spite of its small size (only 12,500 words), it is substantial in content. This ancient treatise systematically discussed land utilization, giving priority to agricultural techniques of the rice-growing regions south of the Changjiang (Yangtze) River. The author provides a general view of intercropping and preservation of soil fertility using comprehensive measures.

Multi-component systems were recorded in *Wang Zheng Nong Shu* (Agricultural Treatise by Wang Zheng) in the Yuan Dynasty (1271–1368). Wang Zheng was a local administrative officer in the area now called Anhui and Jiangxi, who often visited rural areas for inspections and was very interested in agricultural production. This treatise sums up the production practice of dry farmland cultivation in the Yellow River plain and paddy-rice cultivation in the Yangtze River Basin. Its present edition has about 110,000 words and is divided into three parts: *Nong Song Tong Jue* (General Survey of Agriculture and Silviculture), *Bai Gu Pu* (Guide to a Hundred Cereals), and *Nong Qi Tu Pu* (A Collection of Illustrative Plates for Agricultural Implements). Wang Zheng summarized the various technologies and experiences in farming, forestry, animal husbandry, sideline production and fishery and discussed the fitness of season and soil. The farming chart is a praiseworthy creation of Wang Zheng: ingeniously combining constellation periodicity, seasons, natural signs and procedures of agricultural production into an organic whole, it puts together all the main points of *Nong Jia Yue Ling* (Monthly Ordinances for Farmers) and sums them up in a small chart which is clear, definite, handy and very practical (Figure 9.1).

Another example is fishery in paddy fields. In *Ling Biao Lu Yi*, written during the Tang Dynasty, it was described that 'putting the eggs of grass carp into paddy fields, when fish grow up, the roots of weeds were eaten up and the field is fertilized. Consequently the rice can yield a good harvest.'

Another excellent example of Chinese people in development of traditional ecological farming is the now world-famous dyke-pond system, or so-called integrated agriculture–aquaculture system (Zhong et al, 1987). China has a long history of mulberry planting, silkworm rearing and silk reeling and weaving. The integration of aquaculture and agriculture systems and silviculture is an old, widespread and enduring practice in south and south-east China. According to the literature, such systems existed in the Tang Dynasty (7th century AD), but did not flourish until the 14th century of the Yuan Dynasty. In the Zhujiang Delta ponds were dug to drain marshes and natural ponds in order to create arable land, and the excavated soil was used to construct dykes. The first commercial crops grown on the dykes were fruits, particularly litchi and longan, while the early artificial ponds were utilized for breeding and rearing fish for sale. However, there was apparently little or no conscious organization of an integrated fruit dyke–fishpond system in terms of linked input and output of material and energy, although both



Source: Agricultural Treatise of Wang Zheng

Figure 9.1 *The farming chart in Wang Zheng Nong Shu*

activities might be going on at the same farm unit. By 1620, however, mulberry was widely cultivated on the dykes between the fishponds. Experience has shown that economic returns from integrated mulberry dyke–fishpond systems were greater than those obtained from cultivating fruit trees on the dykes. Moreover, pond mud enriched with silkworm excrement and other wastes that had been first used to fertilize the pond and feed the fish was found to be a superior fertilizer for mulberry bushes than raw silkworm excrement which, when applied to excess, damaged mulberry leaves. With this discovery an integrated dyke–pond system was found to be beneficial to both mulberry and fish, and far better than growing rice.

Thoughts and practices in the Ming and Qing Dynasties

Nong Zheng Quan Shu (Complete Treatise on Agriculture), an unprecedented monumental work compiled by Xu Guangqi (1562–1633), an outstanding scientist of the Ming Dynasty (1368–1644), in mathematics and astronomy as well as use of the lunar calendar. This book contains more than 700,000 words and makes use of 229 written documents. It is the most comprehensive of all works on agriculture up to that time. The 60 volumes of the book are divided into 12 sections:

1 agriculture as the foundation (classics, history, literary references, various schools of thought, miscellaneous essays, studies of various dynasty's policies stressing agriculture);

2 farmland systems;
3 farming (management and administration, land reclamation, issuing almanacs for enforcement, divination of seasons);
4 water conservancy;
5 agricultural implements;
6 cultivation;
7 sericulture;
8 extension of sericulture;
9 planting (cash crops);
10 animal husbandry;
11 processing and construction;
12 protection against disaster.

Many advanced thoughts on ecological and successful technologies were introduced in this treatise, including presentation of the intercropping system. For example, the well-known Tangua system has been shown to be the earliest practice in formulation of agroforestry. In fact, similar practices had been implemented in China and were recorded in the literature at least 200 years earlier than those reported in Myanmar. A detailed description on planting crops is described in *Nong Zheng Quan Shu*. During the first few years of establishment of young stands of Chinese fir, cereal crops can be cultivated between the rows of trees. This tree/crop interplanting system can accelerate the growth of both tree and crops to make full use of space. Xu Guangqi also introduced the technology of making sheepfolds on the banks of fishponds and sweeping the manure on the bank into the pond to feed the fish.

In *Zhi Huang Quan Shu* (A Monograph on the Control of Locusts), written in the Qing Dynasty, an example of using ducks to control pests was given: in a mountain region, the locusts were caught by 700 ducks. Besides, raising ducks in paddy fields could also help to catch other leafhoppers.

The *Bu Nong Shu* (Additional Farming Book), written more than 300 years ago, stated that 'The manure of human and other animals as well as ash and dirt will become food and clothes soon if they are put into fields.' Farming, animal husbandry and composting were tightly combined in order to preserve biodiversity in the agriculture system. Crop stalks, manure of human and animals, organic wastes, etc. were put together to make compost, then applied into fields on the basis of 'come from soil, return to soil'. In this book an integrated system in the low wetlands of Zhejiang Province was described in which grain crops and mulberry trees were planted and fish and livestock were raised. By the end of the Qing Dynasty (1911), the Pearl River (Zhujiang) Delta had this kind of agroecosystem developed in some 66,700ha, and by 1925, at the peak of Guangdong silk production, 93,000ha of dykes were planted with mulberry. But a massive decline was soon to set in with the worldwide Great Depression.

The excellent techniques used in the planning of farm landscapes of traditional agriculture in China included information on tall and short crops, trailing and erect stem plants, deep- and shallow-rooted plants, sun-loving plants and shade resistance, early and lately maturing varieties. These characteristics were expanded to include all land resources within the organic combination of agriculture, forestry, animal husbandry, fishery and sideline production, together with comprehensive development and beneficial recycling systems. In the Qing Dynasty four methods of raising fish with different foods and living condition were combined in the same pond to maximize use of the water, to save on bait and to increase efficiency. The system, in which grass carp, silver carp, variegated carp and common carp were fed in the same waterbody to rationally utilize the water, save forage and increase benefits, is still used nowadays.

A large variety of aquaculture and agriculture interactive systems have been developed in China. Sugarcane has been cultivated on the dykes since the beginning of this [20th] century. Despite the widespread adoption of sugarcane cultivation, many former mulberry dykes were converted to vegetable production or paddy rice. Historically, although excavation of fishponds and dyke construction is considered to be the best way of transforming formerly economically marginal areas, subject to a range of natural disasters, until 1949 cropping patterns on the dykes were dictated by market prices rather than by ecological considerations.

In the *Wei Ya Wen Ji* (Collected Works of Wei Ya Wen) written in the Ming Dynasty, it was recorded that a variety of small crab lived in paddy field and fed on tender sprouts of rice. To control this little crab, the local farmers raised ducks in the paddy. As a result, ducks produced meat and eggs, the paddy fields were fertilized by the manure of ducks and the little crabs and insect pests were devoured by the fish.

During the Ming and Qing Dynasties, multiple cropping spread throughout north and south China. In the *Jiang Nan Cui Geng Ke Dao Biao* (The Situation of Rice in South China), Li Yanzhang summarized the growing of double-harvest rice on wheat stubble in the south of the Yangtze River, in which barley was harvested in the last ten days of March and the wheat was harvested in the first ten days of April. Seed soaking was done in the first ten days of March and on 30 March the rice seedlings germinated. After the harvest of wheat, the fields were fertilized, ploughed and raked and then rice seedlings were transplanted. In this way, three harvests in one year are realized. In Hunan Province, beans were planted after rice harvesting, and ripened in winter; then wheat was planted in the field and ripened in the next summer, followed by rice, etc.

Development of Modern IFS

Rapid development and upgrading of knowledge in IFS

Since the founding of the People's Republic of China in 1949, there has been a rapid growth in population and the economy, together with a decrease in arable land and a deterioration in the environment. However, IFS has been revived and developed on an ever-wider scale and upgraded on the basis of modern science. For example, some very interesting results have been obtained on energy flow and nutrient cycles of some systems and systems dynamics analysis and simulation have been initiated. At the same time, many experimental farms and field stations have been established. These are important bases for scientific research as well as important areas for demonstration and extension to vast areas.

A monograph entitled *Agroecological Engineering in China*, edited by Ma Shijun and Li Songhua (1987), provides a review of the concepts, history, principles, major types, methods of analysis and assessment, as well as perspectives of implementation of IFS in China. Many other publications have expounded the structure and benefits of specific types of IFS. Although interesting facts and encouraging results have confirmed the great potential and inherent advantages in this system, most of these publications remain descriptive and qualitative rather than analytical, quantitative studies. Nevertheless, a few interesting projects have emerged in which systematic, in-depth studies were carried out. For example, the rubber/tea intercropping system, widely practised in tropical regions, has been subjected to detailed studies by the Yunnan Institute of Ecology and the Reclamation Bureau of Hainan Province. The most popular and successful model, the *Paulownia* intercropping system, was studied by the Chinese Academy of Forestry Sciences and other local institutions. It is of particular value to mention the work of Zhong Gongfu and his colleagues who have studied the terrestrial/aquatic interactive system in the Zhujiang (Pearl River) Delta in Guangdong Province since the early 1950s and published *Integrated Agriculture/Aquaculture in South China* in 1988. This examined the historical development, agricultural and aquacultural components, energy flow, labour requirements and household economics of the system and is the first ever broad analysis of any such traditional integrated system (Ruddle and Zhong, 1988).

Many films and videos have been created to introduce integrated farming projects and specific technology useful in this system. In recent years, a number of national and international symposia/workshops have been organized by the Chinese Academy of Sciences, Ministry of Agriculture and the Ecological Society of China. All of these have provided a sound basis for further development of the integrated systems in China.

Improvement of production organization and agricultural policies

Policies play an important role in the development of IFS. Before 1987 the agricultural administrative system of China had assumed the familiar three-tier form of the People's Commune, Production Brigade and Production Team. Nevertheless, the household remained the smallest single unit of Chinese social organization and one in which the *de facto* use and management of privately owned resources, such as small homestead garden plots and domestic animals, was vested.

Since December 1978 the notion of a highly collectivized and egalitarian society has gradually been repudiated. China has moved towards the creation of a mixed, state-owned, marketing economy with rural reforms giving more flexibility to individual householders. This has led to decollectivization of many agricultural practices, transforming the status of the individual family to the basic rural economic unit from *de facto* to *de jure*.

As a consequence of these reforms, most areas in rural China now practise some form of responsibility system, with land and production contracted either to individual households or to the production team. Since 1981 the government has devoted much effort to stabilize the present ownership structure of hills and forests, allotting hillsides to peasants for their private use and setting up the forest production responsibility system throughout the country. Barren hills and flood plains owned by the collectives have been offered partly or entirely to peasants to be used privately in a way consistent with their desires and management ability. The trees and grass growing on lots belong to the landholders, who are entitled to manage their allotments on a long-term basis. Allotments can also be inherited, and young trees and half-mature trees on these may be exchanged for money. Trees of economic value, e.g. bamboo groves and shelterbelts owned by a collective, can be either contracted to specialized teams or groups or to households. The opening and development of free markets has encouraged farmers to produce diversified products. In addition, rural village industries have developed rapidly. Some 1.56 million 'township enterprises' have been established, employing around 70 million workers. These are capable of processing some agricultural products. All these reforms and policies not only are economically successful but also promote the enthusiasm of the farmers to develop a diversified IFS in China.

Support and incentives from the government

The support and incentives provided by the government are indispensable for the rapid development of IFS. Because the concept of ecoagriculture conforms to the basic strategy for development of agriculture, the Chinese Government attaches great importance to its development. In 1984, the State Council formally promulgated a decision on further expanding ecological agriculture in China. Soon after that the Eighth Five-Year National Development Plan decided to develop demonstration engineering for ecological agriculture. The requirement for conservation of national resources and development of ecoagriculture has been explicitly delineated in the Ninth Five-Year Plan for development of the national economy and society. The comprehensive management for sustainable agricultural development has been emphasized in China's Agenda 21, a significant national document for further domestic economic growth and medium- to long-term development and was approved by the State Council on 25 March 1994 in the form of the White Paper on China's Population, Environment and Development in the Twenty-first Century. Due to stimulation from government at various levels, ecoagriculture has been developed rapidly and profitably from household, to village, to county, as well as the regional level. In 1993, a leading group for the construction of eco-counties was approved by the State Council. This cross-ministry organization consists of representatives of the Ministry of Agriculture, the State Planning Commission, the National Environmental Protection Agency, the State Science and Technology Commission, the Ministry of Finance, the Ministry of Forestry and the Ministry of Water Resources.

The need for incentives to encourage farmers to adopt IFS practice, particularly the initial stages, is well recognized, as farmers do not have the resources to invest in reforming their conventional mono-cultivation system into a diversified integrated system. There are many forms of incentives in China; some direct and others indirect. Direct incentives include subsidies and loans to the farmers. Indirect incentives include technical assistance, tax exemption, tax deductions, security in land tenure, and marketing services. The goal of the incentive schemes is to encourage eventual self-reliance on the part of the farmer and the community and should fit in both short- and long-range plans.

By 1999, 51 counties contained trial sites for implementation of IFS. Although these sites are varied in scale as well as in physical and social conditions, most have obtained remarkable results. In 2000, another 100 counties were selected as trial sites. Therefore, China's IFS, or ecological agriculture, with a long history of development in ancient China, has been enriched and upgraded with the progress of modern science and technology, and has gradually become a real approach for sustainable agriculture.

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10

Farmers of Forty Centuries

F. H. King

A word of introduction is needed to place the reader at the best viewpoint from which to consider what is said in the following pages regarding the agricultural practices and customs of China, Korea and Japan. It should be borne in mind that the great factors which today characterize, dominate and determine the agricultural and other industrial operations of Western nations were physical impossibilities to them 100 years ago, and until then had been so to all people.

It should be observed, too, that the US as yet is a nation of but few people widely scattered over a broad virgin land with more than 20 acres to the support of every man, woman and child, while the people whose practices are to be considered are toiling in fields tilled more than 3000 years and who have scarcely more than two acres per capita,[1] more than one-half of which is uncultivable mountain land.

Again, the great movement of cargoes of feeding stuffs and mineral fertilizers to western Europe and to the eastern US began less than a century ago and has never been possible as a means of maintaining soil fertility in China, Korea or Japan, nor can it be continued indefinitely in either Europe or America. These importations are for the time making tolerable the waste of plant food materials through our modern systems of sewage disposal and other faulty practices; but the Mongolian races have held all such wastes, both urban and rural, and many others which we ignore, sacred to agriculture, applying them to their fields.

We are to consider some of the practices of a virile race of some 500 millions of people who have an unimpaired inheritance moving with the momentum acquired through 4000 years; a people morally and intellectually strong, mechanically capable, who are awakening to a utilization of all the possibilities which science and invention during recent years have brought to Western nations; and a people who have long dearly loved peace but who can and will fight in self-defence if compelled to do so.

We had long desired to stand face to face with Chinese and Japanese farmers; to walk through their fields and to learn by seeing some of their methods, appliances and practices which centuries of stress and experience have led these oldest farmers in the world to adopt. We desired to learn how it is possible, after 20 and

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perhaps 30 or even 40 centuries, for their soils to be made to produce sufficiently for the maintenance of such dense populations as are living now in these three countries. We have now had this opportunity and almost every day we were instructed, surprised and amazed at the conditions and practices which confronted us whichever way we turned; instructed in the ways and extent to which these nations for centuries have been and are conserving and utilizing their natural resources, surprised at the magnitude of the returns they are getting from their fields, and amazed at the amount of efficient human labour cheerfully given for a daily wage of five cents and their food, or for 15 cents, US currency, without food.

The three main islands of Japan in 1907 had a population of 46,977,003 maintained on 20,000 square miles of cultivated field. This is at the rate of more than three people to each acre, and of 2349 to each square mile; and yet the total agricultural imports into Japan in 1907 exceeded the agricultural exports by less than one dollar per capita. If the cultivated land of Holland is estimated at but one-third of her total area, the density of her population in 1905 was, on this basis, less than one-third that of Japan in her three main islands. At the same time Japan is feeding 69 horses and 56 cattle, nearly all labouring animals, to each square mile of cultivated field, while we were feeding in 1900 but 30 horses and mules per same area, these being our labouring animals.

As coarse food transformers Japan was maintaining 16,500,000 domestic fowl, 825 per square mile, but only one for almost three of her people. We were maintaining, in 1900, 250,600,000 poultry, but only 387 per square mile of cultivated field and yet more than three for each person. Japan's coarse food transformers in the form of swine, goats and sheep aggregated but 13 to the square mile and provided but one of these units for each 180 of her people; while in the US in 1900 there were being maintained, as transformers of grass and coarse grain into meat and milk, 95 cattle, 99 sheep and 72 swine per each square mile of improved farms. In this reckoning each of the cattle should be counted as the equivalent of perhaps five of the sheep and swine, for the transforming power of the dairy cow is high. On this basis we are maintaining at the rate of more than 646 of the Japanese units per square mile, and more than five of these to every man, woman and child, instead of one to every 180 of the population, as is the case in Japan.

Correspondingly accurate statistics are not accessible for China but in the Shantung province we talked with a farmer having 12 in his family and who kept one donkey, one cow, both exclusively labouring animals, and two pigs on 2.5 acres of cultivated land where he grew wheat, millet, sweet potatoes and beans. Here is a density of population equal to 3072 people, 256 donkeys, 256 cattle and 512 swine per square mile. In another instance where the holding was one and two-thirds acres the farmer had 10 in his family and was maintaining one donkey and one pig, giving to this farm land a maintenance capacity of 3840 people, 384 donkeys and 384 pigs to the square mile, or 240 people, 24 donkeys and 24 pigs to one of our 40-acre farms which our farmers regard too small for a single family. The average of seven Chinese holdings which we visited and where we obtained similar data indicates a maintenance capacity for those lands of 1783 people, 212 cattle or donkeys and 399 swine – 1995 consumers and 399 rough food transformers per square mile of farm land. These statements for China represent strictly rural populations. The rural population of the US in 1900 was placed at the rate of 61 per square mile of improved farm land and there were 30 horses and mules. In Japan the rural population had a density in 1907 of 1922 per square mile, and of horses and cattle together 125.

The population of the large island of Chungming in the mouth of the Yangtse river, having an area of 270 square miles, possessed, according to the official census of 1902, a density of 3700 per square mile and yet there was but one large city on the island, hence the population is largely rural.

It could not be other than a matter of the highest industrial, educational and social importance to all nations if there might be brought to them a full and accurate account of all those conditions which have made it possible for such dense populations to be maintained so largely upon the products of Chinese, Korean and Japanese soils. Many of the steps, phases and practices through which this evolution has passed are irrevocably buried in the past but such remarkable maintenance efficiency attained centuries ago and projected into the present with little apparent decadence merits the most profound study and the time is fully ripe when it should be made. Living as we are in the morning of a century of transition from isolated to cosmopolitan national life when profound readjustments, industrial, educational and social, must result, such an investigation cannot be made too soon. It is high time for each nation to study the others and by mutual agreement and cooperative effort, the results of such studies should become available to all concerned, made so in the spirit that each should become coordinate and mutually helpful component factors in the world's progress.

One very appropriate and immensely helpful means for attacking this problem, and which should prove mutually helpful to citizen and state, would be for the higher educational institutions of all nations, instead of exchanging courtesies through their baseball teams, to send select bodies of their best students under competent leadership and by international agreement, both east and west, organizing therefrom investigating bodies each containing components of the Eastern and Western civilization and whose purpose it should be to study specifically set problems. Such a movement well conceived and directed, manned by the most capable young men, should create an international acquaintance and spread broadcast a body of important knowledge which would develop as the young men mature and contribute immensely toward world peace and world progress. If some broad plan of international effort such as is here suggested were organized the expense of maintenance might well be met by diverting so much as is needful from the large sums set aside for the expansion of navies, for such steps as these, taken in the interests of world uplift and world peace, could not fail to be more efficacious and less expensive than increase in fighting equipment. It would cultivate the spirit of pulling together and of a square deal rather than one of holding aloof and of striving to gain unneighbourly advantage.

Many factors and conditions conspire to give to the farms and farmers of the Far East their high maintenance efficiency and some of these may be succinctly stated. The portions of China, Korea and Japan where dense populations have developed and are being maintained occupy exceptionally favourable geographic positions so far as these influence agricultural production. Canton in the south of China has the latitude of Havana, Cuba, while Mukden in Manchuria, and northern Honshu in Japan are only as far north as New York city, Chicago and northern California. The US lies mainly between 50° and 30° of latitude while these three countries lie between 40° and 20°, some 700 miles further south. This difference of position, giving them longer seasons, has made it possible for them to devise systems of agriculture whereby they grow two, three and even four crops on the same piece of ground each year. In southern China, in Formosa and in parts of Japan two crops of rice are grown; in the Chekiang province there may be a crop of rape, of wheat or barley or of Windsor beans or clover which is followed in midsummer by another of cotton or of rice. In the Shantung province wheat or barley in the winter and spring may be followed in summer by large or small millet, sweet potatoes, soybeans or peanuts. At Tientsin, 39° north, in the latitude of Cincinnati, Indianapolis and Springfield, Illinois, we talked with a farmer who followed his crop of wheat on his smallholding with one of onions and the onions with cabbage, realizing from the three crops at the rate of $163, gold, per acre; and with another who planted Irish potatoes at the earliest opportunity in the spring, marketing them when small, and following these with radishes, the radishes with cabbage, realizing from the three crops at the rate of $203 per acre.

Nearly 500,000,000 people are being maintained, chiefly upon the products of an area smaller than the improved farm lands of the US. Complete a square on the lines drawn from Chicago southward to the Gulf and westward across Kansas, and there will be enclosed an area greater than the cultivated fields of China, Korea and Japan and from which five times our present population are fed.

The rainfall in these countries is not only larger than that even in our Atlantic and Gulf states, but it falls more exclusively during the summer season when its efficiency in crop production may be highest. South China has a rainfall of some 80 inches with little of it during the winter, while in our southern states the rainfall is nearer 60 inches with less than one-half of it between June and September. Along a line drawn from Lake Superior through central Texas the yearly precipitation is about 30 inches but only 16 inches of this falls during the months May to September; while in the Shantung province, China, with an annual rainfall of little more than 24 inches, 17 of these fall during the months designated and most of this in July and August. When it is stated that under the best tillage and with no loss of water through percolation, most of our agricultural crops require 300 to 600 tons of water for each ton of dry substance brought to maturity, it can be readily understood that the right amount of available moisture, coming at the proper time, must be one of the prime factors of a high maintenance capacity for any soil, and hence that in the Far East, with their intensive methods, it is possible to make their soils yield large returns.

The selection of rice and of the millets as the great staple food crops of these three nations, and the systems of agriculture they have evolved to realize the most from them, are to us remarkable and indicate a grasp of essentials and principles which may well cause Western nations to pause and reflect.

Notwithstanding the large and favourable rainfall of these countries, each of the nations have selected the one crop which permits them to utilize not only practically the entire amount of rain which falls upon their fields, but in addition enormous volumes of the run-off from adjacent uncultivable mountain country. Wherever paddy fields are practicable there rice is grown. In the three main islands of Japan 56 per cent of the cultivated fields, 11,000 square miles, is laid out for rice growing and is maintained under water from transplanting to near harvest time, after which the land is allowed to dry, to be devoted to dry land crops during the balance of the year, where the season permits.

To anyone who studies the agricultural methods of the Far East in the field it is evident that these people, centuries ago, came to appreciate the value of water in crop production as no other nations have. They have adapted conditions to crops and crops to conditions until with rice they have a cereal which permits the most intense fertilization and at the same time the ensuring of maximum yields against both drought and flood. With the practice of Western nations in all humid climates, no matter how completely and highly we fertilize, in more years than not yields are reduced by a deficiency or an excess of water.

It is difficult to convey, by word or map, an adequate conception of the magnitude of the systems of canalization which contribute primarily to rice culture. A conservative estimate would place the miles of canals in China at fully 200,000 and there are probably more miles of canal in China, Korea and Japan than there are miles of railroad in the US. China alone has as many acres in rice each year as the US has in wheat and her annual product is more than double and probably threefold our annual wheat crop, and yet the whole of the rice area produces at least one and sometimes two other crops each year.

The selection of the quick-maturing, drought-resisting millets as the great staple food crops to be grown wherever water is not available for irrigation, and the almost universal planting in hills or drills, permitting intertillage, thus adopting centuries ago the utilization of earth mulches in conserving soil moisture, has enabled these people to secure maximum returns in seasons of drought and where the rainfall is small. The millets thrive in the hot summer climates; they survive when the available soil moisture is reduced to a low limit, and they grow vigorously when the heavy rains come. Thus we find in the Far East, with more rainfall and a better distribution of it than occurs in the US, and with warmer, longer seasons, that these people have with rare wisdom combined both irrigation and dry farming methods to an extent and with an intensity far beyond anything our people have ever dreamed, in order that they might maintain their dense populations.

Notwithstanding the fact that in each of these countries the soils are naturally more than ordinarily deep, inherently fertile and enduring, judicious and rational methods of fertilization are everywhere practised; but not until recent years, and only in Japan, have mineral commercial fertilizers been used. For centuries, however, all cultivated lands, including adjacent hill and mountain sides, the canals, streams and the sea have been made to contribute what they could toward the fertilization of cultivated fields and these contributions in the aggregate have been large. In China, in Korea and in Japan all but the inaccessible portions of their vast extent of mountain and hill lands have long been taxed to their full capacity for fuel, lumber and herbage for green manure and compost material; and the ash of practically all of the fuel and of all of the lumber used at home finds its way ultimately to the fields as fertilizer.

In China enormous quantities of canal mud are applied to the fields, sometimes at the rate of even 70 and more tons per acre. So, too, where there are no canals, both soil and subsoil are carried into the villages and there between the intervals when needed they are, at the expense of great labour, composted with organic refuse and often afterwards dried and pulverized before being carried back and used on the fields as home-made fertilizers. Manure of all kinds, human and animal, is religiously saved and applied to the fields in a manner which secures an efficiency far above our own practices. Statistics obtained through the Bureau of Agriculture, Japan, place the amount of human waste in that country in 1908 at 23,950,295 tons, or 1.75 tons per acre of her cultivated land. The International Concession of the city of Shanghai, in 1908, sold to a Chinese contractor the privilege of entering residences and public places early in the morning of each day in the year and removing the night soil, receiving therefore more than $31,000, gold, for 78,000 tons of waste. All of this we not only throw away but expend much larger sums in doing so.

Japan's production of fertilizing material, regularly prepared and applied to the land annually, amounts to more than 4.5 tons per acre of cultivated field exclusive of the commercial fertilizers purchased. Between Shanhaikwan and Mukden in Manchuria we passed, on 18 June, thousands of tons of the dry highly nitrified compost soil recently carried into the fields and laid down in piles where it was waiting to be 'fed to the crops'.

It was not until 1888, and then after a prolonged war of more than 30 years, generalled by the best scientists of all Europe, that it was finally conceded as demonstrated that leguminous plants acting as hosts for lower organisms living on their roots are largely responsible for the maintenance of soil nitrogen, drawing it directly from the air to which it is returned through the processes of decay. But centuries of practice had taught the Far East farmers that the culture and use of these crops are essential to enduring fertility, and so in each of the three countries the growing of legumes in rotation with other crops vary extensively for the express purpose of fertilizing the soil is one of their old, fixed practices.

Just before, or immediately after the rice crop is harvested, fields are often sowed to 'clover' (*Astragalus sinicus*) which is allowed to grow until near the next transplanting time when it is either turned under directly, or more often stacked along the canals and saturated while doing so with soft mud dipped from the bottom of the canal. After fermenting 20 or 30 days it is applied to the field. And so it is literally true that these old world farmers whom we regard as ignorant, perhaps because they do not ride sulky ploughs as we do, have long included legumes in their crop rotation, regarding them as indispensable.

Time is a function of every life process as it is of every physical, chemical and mental reaction. The husbandman is an industrial biologist and as such is compelled to shape his operations so as to conform with the time requirements of his crops. The oriental farmer is a time economizer beyond all others. He utilizes the first and last minute and all that are between. The foreigner accuses the Chinaman of being always long on time, never in a fret, never in a hurry. This is quite true and made possible for the reason that they are a people who definitely set their faces towards the future and lead time by the forelock. They have long realized that much time is required to transform organic matter into forms available for plant food and although they are the heaviest users in the world, the largest portion of this organic matter is predigested with soil or subsoil before it is applied to their fields, and at an enormous cost of human time and labour, but it practically lengthens their growing season and enables them to adopt a system of multiple cropping which would not otherwise be possible. By planting in hills and rows with intertillage it is very common to see three crops growing upon the same field at one time, but in different stages of maturity, one nearly ready to harvest; one just coming up, and the other at the stage when it is drawing most heavily upon the soil. By such practice, with heavy fertilization, and by supplemental irrigation when needful, the soil is made to do full duty throughout the growing season.

Then, notwithstanding the enormous acreage of rice planted each year in these countries, it is all set in hills and every spear is transplanted. Doing this, they save in many ways except in the matter of human labour, which is the one thing they have in excess. By thoroughly preparing the seed bed, fertilizing highly and giving the most careful attention, they are able to grow on one acre, during 30 to 50 days, enough plants to occupy ten acres and in the mean time on the other nine acres crops are maturing, being harvested and the fields being fitted to receive the rice when it is ready for transplanting, and in effect this interval of time is added to their growing season.

Silk culture is a great and, in some ways, one of the most remarkable industries of the Orient. Remarkable for its magnitude; for having had its birthplace apparently in oldest China at least 2700 years BC; for having been laid on the domestication of a wild insect of the woods; and for having lived through more than 4000 years, expanding until a million-dollar cargo of the product has been laid down on our western coast and rushed by special fast express to the east for the Christmas trade.

A low estimate of China's production of raw silk would be 120,000,000 pounds annually, and this with the output of Japan, Korea and a small area of southern Manchuria, would probably exceed 150,000,000 pounds annually, representing a total value of perhaps $700,000,000, quite equalling in value the wheat crop of the US, but produced on less than one-eighth the area of our wheat fields.

The cultivation of tea in China and Japan is another of the great industries of these nations, taking rank with that of sericulture if not above it in the important part it plays in the welfare of the people. There is little reason to doubt that this industry has its foundation in the need of something to render boiled water palatable for drinking purposes. The drinking of boiled water is universally adopted in these countries as an individually available and thoroughly efficient safeguard against that class of deadly disease germs which thus far it has been impossible to exclude from the drinking water of any densely peopled country.

Judged by the success of the most thorough sanitary measures thus far instituted, and taking into consideration the inherent difficulties which must increase enormously with increasing populations, it appears inevitable that modern methods must ultimately fail in sanitary efficiency and that absolute safety can be secured only in some manner having the equivalent effect of boiling drinking water, long ago adopted by the Mongolian races.

In the year 1907 Japan had 124,482 acres of land in tea plantations, producing 60,877,975 pounds of cured tea. In China the volume annually produced is much larger than that of Japan, 40,000,000 pounds going annually to Tibet alone from the Szechwan province; and the direct export to foreign countries was, in 1905, 176,027,255 pounds, and in 1906 it was 180,271,000, so that their annual export must exceed 200,000,000 pounds with a total annual output more than double this amount of cured tea.

But above any other factor, and perhaps greater than all of them combined in contributing to the high maintenance efficiency attained in these countries, must be placed the standard of living to which the industrial classes have been compelled to adjust themselves, combined with their remarkable industry and with the most intense economy they practise along every line of effort and of living.

Almost every foot of land is made to contribute material for food, fuel or fabric. Everything which can be made edible serves as food for man or domestic animals. Whatever cannot be eaten or worn is used for fuel. The wastes of the body, of fuel and of fabric worn beyond other use are taken back to the field; before doing so they are housed against waste from weather, compounded with intelligence and forethought and patiently laboured with through one, three or even six months, to bring them into the most efficient form to serve as manure for the soil or as feed for the crop. It seems to be a golden rule with these industrial classes, or if not golden, then an inviolable one, that whenever an extra hour or day of labour can promise even a little larger return then that shall be given, and neither a rainy day nor the hottest sunshine shall be permitted to cancel the obligation or defer its execution.

Note

1 This figure was wrongly stated in the first edition as 1 acre, owing to a mistake in confusing the area of cultivated land with total area.

Part III

Agricultural Revolutions and Change

11

Agricultural Sustainability and Open-Field Farming in England, c. 1650–1830

Michael Turner, John Beckett and Bethanie Afton

Introduction

Sustainability has become a key concept in the modern approach to development studies. The guiding definition proposed in 1987 by the World Commission on Environment and Development (Brundtland Commission) emphasized that 'Sustainable development is that development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs' (World Commission, 1987, p144). To that extent sustainability was regarded as something to be achieved in the future, which can in turn lead to a view of the past in which everything had been sustainable, but this was a state of affairs that had only recently changed or was in danger of changing. Thus Conway and Pretty (1991, p1) invoke a distant past (or certainly the pre-1945 period), in heralding the problems of the present or very recent past in agricultural development:

> … agriculture, for most of its history, has been environmentally benign. Even when industrial technology began to have an impact in the eighteenth and nineteenth centuries, agriculture continued to rely on natural ecological processes. Crop residues were incorporated into the soil or fed to livestock, and the manure returned to the land in amounts that could be absorbed and utilised. The traditional mixed farm was a closed, stable and sustainable ecological system, generating few external impacts. Since the Second World War this system had disintegrated. (Conway and Pretty, 1991, p1)

This suggests that there are lessons for the future that might be drawn from the past. In this sense Pretty's (1991) summary of extension practices in the classical British 'Agricultural Revolution' demonstrated the way the past has sometimes prefigured the future.

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Nevertheless, the late 20th-century agricultural revolution in industrialized countries suggests a quantum leap in modern agricultural change. Thus Wes Jackson (1980, pp2–3) pointed to the enormity of the process of post-1945 change: 'So destructive has the agricultural revolution been that, geologically speaking, it surely stands as the most significant and explosive event to appear on the face of the earth…' Yet there is no doubt that in the past there was real ecological stress caused by farming practised in particular contexts. All societies have had to adapt to forces over which they have had little or no control (Mannion, 1995, pp83–84; Evans, 1998, pp57–61). By looking at some specific historical features in the context of the modern debate over sustainability, we may be able to offer some new perspectives on agriculture. The purpose of this paper is to examine the issue of agricultural sustainability specifically in the historical context of open-field farming in the English midland counties. While there is a tradition in agrarian history to address some of the issues that we raise in the paper, we do not think that a concerted attempt has been made to place agricultural or indeed rural history into the holistic framework that we explore here. Standard historical assessments of the past did not have the benefits of modern thinking on sustainability, yet all of them contain elements that might be reconfigured in its language (Tawney, 1912; Hoskins, 1949b; Broad, 1980; Butlin, 1982; Havinden, 1961).

But we believe that this could be a two-way street. While our fellow historians might benefit from the language of the present we wonder whether present environmental concerns about soil, and more widely, resource degradation, and the solutions offered, might reflect that these concerns had been confronted in the past in England. Many local solutions were found by trial and error in the English open fields that in modern parlance (see Wendell Berry's Foreword in Jackson, 1996) might be termed resource management schemes.

The Geographical and Chronological Context

Our focus of attention in this paper is specific. We concentrate on the open-field farming system that prevailed over much of England until its final dissolution in the 80 or so years after 1750. This was a system that was based on communally administered agricultural organization and production, and it persisted, sometimes without any major adjustments, for several centuries. It was part of the northern European system of communal agriculture, though most historians would recognize significant regional variations even within the confines of the British Isles (Baker and Butlin, 1973). The study of the system has relatively recently undergone renewed attention under the gaze of New Institutional Economics. This relates to collective action and land rights, by which route it has modern applications in quite diverse societies and contexts (see for example Hardin, 1968; Ostrom, 1990; Baland and Platteau, 1998). While open-field farming in communally organized ways prevailed to a greater or lesser degree over nearly all of England, it was most prevalent and survived longest in a narrower geographical region. This was particularly concentrated in the midland counties of England. We therefore draw our main references from Bedfordshire, Buckinghamshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire and Rutland, forming a contiguous group of counties in the central and eastern parts of England (though we also include some references to adjacent counties).

An impression of the prevalence and persistence of open-field farming is best demonstrated by measuring its dissolution. There are various ways by which this was achieved, all of which fall under the description of enclosure, but the fullest record of enclosure was undertaken through private and local acts of parliament, most of which changed the farming system from communal to several (private) ownership, and from communal to several administration. This was achieved mainly on a village by village basis (Turner, 1984). Figure 11.1 locates our study area, but in representing the incidence of enclosure in a quantified way it also measures the size of the task that was undertaken, and thereby conveys the importance of the process in the whole history of English agricultural change. The mirror image of enclosure is precisely the dominance of open-field farming. The illustrative village examples we subsequently use demonstrate some of the pressures that open-field farming faced and how they were resisted. However, these pressures were eventually too great to resist the final outcome, which was the ultimate dissolution of the open-field farming system by enclosure.

The Simplified Model

The standard literature of traditional agricultural history has still properly to acknowledge modern methodologies of approach. The core elements of agricultural sustainability that we adopt here first came to our attention through relatively little-known work (Pannell and Schilizzi, 1999), which encouraged a wider review of the literature (to include Norman et al, 1997; Pretty, 2002; Uphoff, 2002; O'Riordan and Stoll-Kleemann, 2003). The core model appropriate to a lengthy historical dimension embraces ecology, economy and equity. The last in this list is our adaptation of what might equally be referred to as ethics. The appropriateness of this adaptation should become apparent as these three elements in the model are applied to our empirical base. In the best of sustainable worlds they should be in harmony. It is when these linkages separated that we conclude that farming in a sustainability framework was at risk.

The principal *ecological* elements of our application of sustainability relate to husbandry practices, and the extent to which these maximized the use of the available land resources without compromising soil quality, soil texture and underlying fertility. This was achieved by using a nutrient recycling regime. However, it must be understood that this took place during a time of relative scientific ignorance, and therefore it was recognized by contemporaries through time-honoured processes. These included the use of tried and tested crop rotations, including experimentation with plants capable of fixing atmospheric nitrogen, even if this scientific

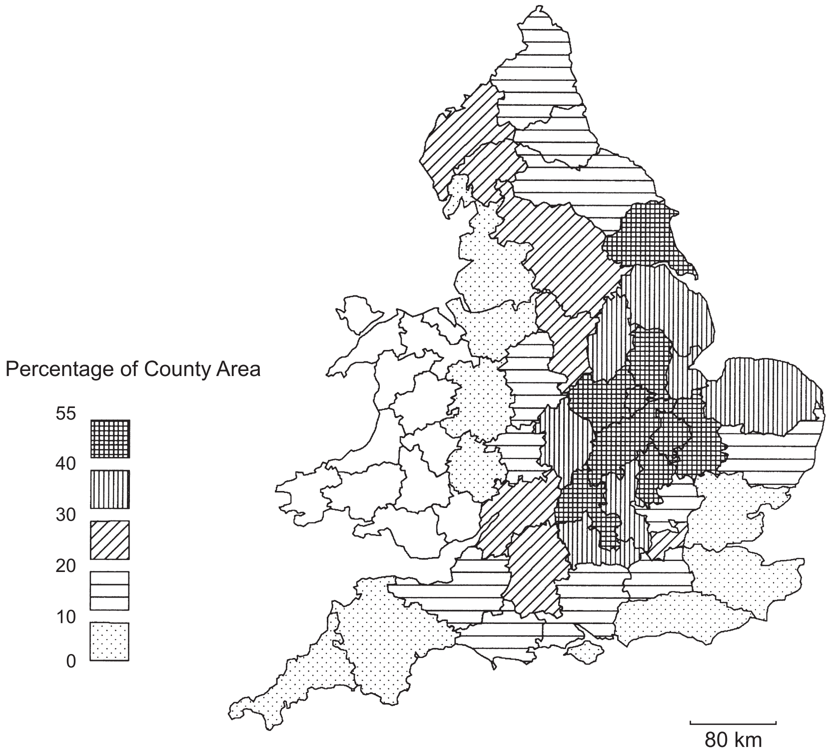

Figure 11.1 *Density of parliamentary enclosure, c. 1740–1840 (England only)*

process was not understood at the time. The end result was the crop, but measured through yields or by the deterioration or improvement in those yields according to the laboratory of experience over the generations. By such methods, for example, medieval farmers in Oxfordshire solved the problem of nitrogen management (Newman and Harvey, 1997). Ecological considerations also involved application of animal manures, and thus returning the nutrients otherwise removed by farming. We take this as a given in modern society, but in the past it came about by experiment and experience. The integration of plants and animals was essential, and in a world of limited resources recycling evolved as the antidote to resource loss. In the words of Sir Albert Howard in 1940 there was an ecological balance in which:

> Mother earth never attempts to farm without livestock; she always raises mixed crops; great pains are taken to preserve the soil and prevent erosion; the mixed vegetable and animal wastes are converted into humus; there is no waste; the processes of growth and the processes of decay balance one another; ample provision is made to maintain large reserves of fertility; the greatest care is taken to store the rainfall; both plants and animals are left to protect themselves from disease. (quoted by Jackson in Soule and Piper, 1992, pxiv)

Successions of farmers mimicked nature but they did this by a process of chance and folk experience rather than by the grand designs that are available in modern agriculture.

The second core element was *economy*, which is recognized as a critical issue in modern literature (Heap, 1992; Gregorich, 1995; Pannell and Schilizzi, 1999). Self-evidently no system is sustainable if farmers go out of business, but the rural community also maintained many other groups and individuals, including landlords, through traditional landlord/tenant relationships, and armies of service providers. The English village evolved as a community of responsible, self-regulating partners, with a duty not simply to the present but also to future generations. Obviously the potential legacy had to be tempered by current need, including a direct income to each generation of farmers. To this extent our characterization of the village community may seem idealized, but periodically the community was subject to risks of shortage and sometimes the ultimate penalty when poor harvests had ensuing mortality consequences. The troughs of hardship were broken up by long periods of, not necessarily plenty, but a less romanticized sufficiency which made communities think about their long-term survival strategies. There have been well-defined periods in English history when the ultimate calamity in agricultural supply resulted in deepest famine and mortality crises, but in the period on which we concentrate, the link between food shortage as measured by adjustments in the relationship of crop and food prices and mortality is statistically weak (Wrigley and Schofield, 1981, pp371–372). We contend that this was because the management of resources, and thus the sustainability of the agricultural system, was successful not least because of the strengths of the communal organization of agriculture. To this extent we are certain that our understanding does not fall foul of a romantic view of the past that tends 'to presume that "tradition" is somehow "good" for ecosystem maintenance' (O'Riordan, 2003, p8). If communal decision making, very often based on tradition, is still very much a feature of non-Western agriculture, then perhaps therein lies a strength rather than a weakness which can be built upon (to this extent many of the modern-day examples in Uphoff, 2002, are built on a tradition of community ownership and participation).

The third core element is *equity*. Farmers were the stewards of the environment they inhabited. In their contemporary language they were judged on whether they cared for the land in a *husbandlike* manner, or with a care for the well-being of the farming habitat. This has always implied ensuring that the soil would retain its fertility. In practice this involved farming in a manner agreed to be the best practice in the locality. However, not all farmers behaved in the same way and with the same attitude of care. Moreover, the resource that delivered the product – the soil itself – was communally administered and subject to a good deal of communal sharing. Therefore good husbandry must not always be assumed, it might have been enforced – through lease covenants for example. Nevertheless, the reward was *equitably* derived in that all participants shared in both the ownership and/or the management of local resources. Disputes over equitable access to these resources were the most common ways in which sustainable agriculture was compromised, hence an elaborate system of manorial and other local courts acted as regulators and policemen within the community. Access to the outcome of farming, to the food itself, also had to be equitable. As in modern societies, so also in the past, there was a basic requirement for secure and adequate food. To that extent we can invoke Sen's modern theory of entitlements. This he related to famines in which supply was not the problem, rather it was the equity of access to that supply that was put at risk. So also in the English open-field village basic output was also adequate but in time there developed a problem over the equity of access to that output (Sen, 1981, 1986).

The Experience of Open-Field England

The textbook management system of the English open fields suggests they operated in a rotational process involving three fields. This simple characterization hides the flexibility and variation within the system. In a study of the organization of Leicestershire church property in the 17th century, Beresford (1949) found that 9 per cent of the parishes for which he had information were more simply arranged in two rather than three fields, 79 per cent were in three, and the remainder in combinations of four, five and more fields. In 18th-century Northamptonshire 57 villages were in four or more fields (Hall, 1995, pp157–164), and although the Nottinghamshire village of Laxton, which incidentally is the last unenclosed example of open-field husbandry to survive on any scale, was a four-field village it was worked on a three-course rotation (Beckett, 1989, pp43–45). Generally in the midland counties each field was divided into a multitude of other units known variously as furlongs, strips and lands, not all of which would necessarily be under the same land use as their neighbours at any one time. For example, at Husbands Bosworth in Leicestershire in 1770, the North Field was divided into 109 arable strips, 56 under temporary grass leys, and 46 in more or less permanent meadow. In the South Field there were 105 strips of arable and 67 in leys, and in West Field there were 102 in arable and 74 in leys (Beresford, 1949). Such divisions within fields made more complex cropping patterns possible, but if we simplify things we recognize three basic 'units' of rotation, the corn crops, the pulses and the fallow. The corn 'unit' was typically sown to barley, wheat or rye (Leicestershire Archives, DE 783/78; Northamptonshire Archives, IL 16).

For much of the early part of the period barley was the most common crop. In Leicestershire, between 1558 and 1608, the acreage of barley averaged between 35 and 40 per cent of the cropped arable. Wheat varied between 8.5 and 14 per cent and rye declined from 8.5 per cent to an insignificant amount by the early 17th century (Hoskins, 1950, pp168, 171; Thirsk, 1954, p212). Barley had the advantage of flexibility in its end use because it could be used for bread and beer production, and also as animal feed, and its straw made fodder and other products.

The flexibility of the open-field system was maximized by having alternative grain crops. For example, wheat and rye were autumn-sown crops, while barley was planted in the spring. Sometimes such flexibility was paramount where the vagaries of the weather in relation to the underlying soil structure demanded it. On the extensive clayland for example, inadequate drainage resulted in excessive water retention and this meant that the period during which the ground could be prepared for cropping was limited. In such circumstances, when there was a delay in the preparation of the ground, the ability to plant a spring-sown crop was not just desirable, it was vital to the general well-being of the community. Yet in some parishes otherwise dominated by the heavy clays, there were also areas where quite different soils also existed. Here the planting of rye provided a good alternative because it could be concentrated in those parts of the open fields least likely to produce good crops of wheat or barley. In such cases it was grown every second or third year (Hoskins, 1950, pp163–165). The inclusion of similar crops that provided such flexibility in response to soil conditions, the weather and the market, went a long way to ensuring the ecological sustainability of the open fields.

In time the growth of the market economy saw adjustments in the grain crop mix, in particular there was a shift towards wheat, which became the premier cash crop. In 32 open-field villages in Bedfordshire in 1801 31 per cent of the arable was under wheat, and 18 per cent under barley. In neighbouring Northamptonshire the equivalent distribution was 31 per cent wheat and 27 per cent barley (Turner, 1989, p52). In comparable Leicestershire villages wheat was planted on between 27 and 30 per cent of the cropped arable in the three open fields, while barley occupied between 18 and 25 per cent (Hoskins, 1949a, pp134–135). Rye remained as the dominant bread grain in much of north and east Europe but by the period under review it was only occasionally planted in England, and then mixed with wheat as a bread grain known regionally as muncorn, maslin, blend corn and other names. By the late 18th century whenever it was grown, however rarely, it was used mainly as an early spring feed crop rather than as a bread grain (Hoskins, 1949b, pp161, 174). By 1801 only 3 per cent of the open fields of Bedfordshire were sown with rye, and less than 1 per cent of those in Northamptonshire (Turner, 1989, p52). Nevertheless, what we can conclude of the bread grains is that within communally administered agricultural systems there was adaptability that had evolved over many generations.

The second part of the rotation was generically known as the pease field (whether it was one or more actual fields), and represented the pulse rotation. Traditionally, beans and peas were planted in the late winter. The land was ploughed typically at Epiphany (6 January), left for a short while so that frost action could break it up further, and then sown. The purpose of this course was mainly as livestock feed. In Leicestershire in the second half of the 16th century, peas (the term was used indiscriminately for both peas and beans) commonly occupied 35–40 per cent of the cropped arable (Hoskins, 1950, pp168, 171; Thirsk, 1954, p212). By 1801 we know that 47 per cent or so of the cropped arable in the Leicestershire villages of Congerstone, Glenfield and Bringhurst was under beans or peas (Hoskins, 1949a, pp134–135), though in the county as a whole the proportion was only 9 per cent. By 1801 much of this county had been enclosed and converted to pasture (Turner, 1981, p296). The balance in other places was quite different: in Bedfordshire 21 per cent of the arable in 32 open-field parishes was under peas and beans, and 29 per cent in 45 Northamptonshire parishes (Turner, 1989, p52).

While pulses are less efficient at fixing atmospheric nitrogen than are small seeded legumes such as clover, trefoil or sainfoin, they would have made at least as important a contribution to the amount of nitrogen in the system thereby helping to ensure the overall sustainability of the arable (Shiel, 1991, p76). The standard model of the nitrogen cycle suggests that grain crops can experience an increase in yields of 15 kilograms for every one kilogram of nitrogen supplied, but this relationship does not expand infinitely. Instead it is driven by Liebig's 'Law of the Minimum' in which the initial nitrogen deficiency is rectified by the fixing of nitrogen from appropriate crops in a more or less linear relationship of 1:15 until such time that a limit is achieved. Beyond this limit further application of nitrogen does not result in further yield improvements. Thus the integral base fertility of the soil was maintained but constantly we need to remind ourselves that this was not scientifically understood. Instead it was a sustainability cycle borne of generations of experience and experimentation. So what might appear as cutting edge innovation in crop mixes was more likely to have evolved through trial and error. For example, oats were occasionally planted in the pease field (Marshall, 1790, p225), but if they were this took place in late spring, and in common with the use of barley in the corn field, they provided a safety net if bad weather had previously prevented farmers from sowing pulses. This safety net ensured sustenance for the animals. The pease or pulse course might occupy as much as 50 per cent of the arable land that was not in fallow, and its principal purpose was to supply fodder for the livestock.

The final course in the rotation was the fallow, which was a restorative period, without the demands of a sown crop. It also acted as a cleaning period, providing an opportunity to remove weeds from the field. Once the pease crop was harvested the field was thrown open for livestock to feed on the stubble, on remnant grasses, weeds and the grass leys. Depasturing also took place on the passageways that afforded access into and across the fields. These were strips of lands known as baulks and headlands. They were integral to the fields and their functions. So also, paradoxically, were weeds. If they were allowed to proliferate at certain times this was not always a sign of backwardness in field management. Arthur Young, the noted agricultural writer and traveller of the late 18th and early 19th centuries observed, 'you cannot clear weeds until first you let them germinate' (Young, 1771, p291). Therefore the fallow field was not normally ploughed in the autumn. Instead the weed seeds were allowed to germinate, thus providing feed for the sheep that were grazed on the fallow. The first ploughing was left until late in the spring (Marshall, 1790, p225; Loudon, 1831, p802; Fox, 1981, pp94–95). A second ploughing was typically made in midsummer, when any weeds which were going to seed were ploughed in before they produced seed heads. A final ploughing occurred about the autumn equinox, shortly before the autumn sowing of the succeeding corn crop. Consequently through the fallow year the field was cleared of sufficient weeds to minimize competition for the limited nutrients available for the future cultivated crops. The groundcover provided by the weeds limited the leaching of nutrients and the erosion of the topsoil. It helped to recycle the nitrogen fixed while the field was in pease. At the same time the field was rested from the demands of a cropping routine, and provided an important source of feed for the sheep, according to the local rules regarding stinting, which in turn provided dung. Thus a neat cycle of nutrient renewal took place year upon year.

The open-field system had evolved in such a way as to be ecologically sustainable. The throughput of crops in the different rotations created a biologically diverse system and the pease field compensated for any shortages of permanent grass, or any tendency to acquire more land under cereal according to temporal economic circumstances. The system minimized losses by maintaining ground cover, and by using a variety of plants it kept nutrients within the system. Recycling, through the actions of the sheep and their digestive system and their natural tendency to tread in their waste, along with the ploughing in of anything left uneaten by the animals, also helped with biodiversity. The principle of farming in nature's image was practised, and the successful integration of plants and animals helped to ensure that the system remained viable across the centuries.

The impact of domestic forces

Seemingly therefore the open-field system was in harmony with sustainable ecological principles while allowing for changes in emphasis at the margin that did not upset the whole system. However, it did not operate in a vacuum. Economic considerations and challenges to equity or fairness had the power to disrupt this ecological balance. In particular there was the impact of large-scale changes in society in general of which the individual villages formed a microcosm. For example, changes in population had an impact on prices and the relative benefits of concentrating on bread foods or the more varied diets offered by a mix of bread and animal products. Yet it was possible for the flexibility of the open-field system to react to such population pressures without initially disrupting what we have described as a sustainable farming system based on open-field management.

From around 5.2 million in c. 1650, the population of England declined to about 4.9 million in 1681, and recovered only slowly to reach 5.8 million by 1751. Only in one half decade from 1681 to 1751 did numbers rise by more than 0.5 per cent per annum and in two half decades the population actually fell (1681–1686 and 1726–1731). On the downturn or during times of relatively stable population the result was cheaper bread for consumers, but farmers found that their incomes were squeezed, especially as corn bounties designed to encourage the export of the grain surplus had only a marginal effect in propping up prices. Grain prices fell steadily from a base of 100 in 1650 to 68 in the mid 1740s with obvious implications for the level of farmers' incomes. As we shall see later, they reacted by

Table 11.1 *Agricultural product price indexes for the main 'Cash Crops' 1650–1812*

Date	*Wheat*	*Butter*	*Milk*	*Beef*	*Mutton*
1650	100	100	100	100	100
1745	68	102	112	103	83
1765	103 (100)	111 (100)	119 (100)	119 (100)	102 (100)
1790	119 (116)	121 (109)	171 (144)	156 (131)	126 (124)
1806	205 (199)	196 (177)	277 (233)	275 (231)	211 (207)
1812	222 (216)	227 (205)	359 (302)	281 (236)	222 (218)

Note: 11-year moving averages, rebased on 1650. Apart from the base in 1650 the years selected are determined by the price of wheat at the maxima, minima, the landmark price when the base price was restored, and when the 200 index barrier was broken. (The index has been rebased in 1765 to show the subsequent relative inflation of prices from the new base.)

Source: Adapted from Clark, 2004

attempting to adjust the ecological balance between grain and animal production. From the mid-18th century population began to rise and prices in turn recovered to the original base 100 by 1765, and then advanced to 119 by 1790. After 1750 the growth of population was uninterrupted and provided some boost to demand and the resulting recovery of prices shown in Table 11.1. In 1751 the population was 5.8 million, and by 1771 it was 6.4 million. By the 1790s it had grown to 7.7 million (in 1791) and on to 8.7 million by 1801 (Schofield, 1994, p64). The conjunction of this population change with the outbreak of war in 1793, a war that lasted more or less continuously until 1815, meant that prices took off, reaching an index on our scale of 200 by 1805 and a high point of 222 by 1812.

This conjunction of demographic and economic circumstances forced agriculturalists to respond by adjusting the ways they worked the land, yet ideally without upsetting the ecological balance or compromising equitable access to resources. The compliance of the landlords and their stewards in this role was also important as witness their abatement of rents during times of economic distress (Turner et al, 1997, *passim*). But there were other ways of adjustment. The balance between arable and pasture or meadow varied between areas and between parishes, and altering this balance was a task for the community. At Withern with Woodthorpe in Lincolnshire, this task is recorded in the Field Reeves Book. It is a record of the annual decisions made about local farming (Lincolnshire Archives, Misc Dep 199/1). In March 1792 it was agreed that the occupiers would seed and stint, that is apportion the use of the fields, as agreed by the majority. The administrators of these decisions and rules (the field reeves) were an elected body and it was up to them to order and direct the management of local drainage, the care of the fields, and the regulation of the numbers of stock that were allowed to graze on the fields at designated times of the year. For example, in November 1799 they agreed to sow the stubble field with corn the 'insuing year owing to the unfavourable state of the fallows in the other field from the excessive wetness of the season'. This was a season by season communal management that was adjusted to accommodate fluctuating annual conditions. In other places such adjustments became permanent features. For example, at Heath and Reach in Bedfordshire it was decided that the traditional three-field system could only be improved by fallowing every fourth year instead of every three. Therefore in 1814 the system of two crops and a fallow became three crops and a fallow in which the third crop was clover, or what others might see as a cropped fallow. It was also agreed that anyone wishing to sow turnip seed or potatoes in the fallow field could do so (Bedfordshire Archives, BO/1334). In Oxfordshire, the open fields were often broken up into larger numbers of rotational units to get around the rigidities of operating only in a two- or three-field manner. At Kirtlington this adaptability reached new heights when 12 arable divisions replaced the original two fields (Lambert, 1955). Such adjustments helped to maintain the ecological integrity of the soil as well as demonstrating equity of ownership through equity of decision making.

We know that in some areas it was possible to modify and adapt the open-field systems to accommodate new crops and new rotations (the examples above and generally in Havinden, 1961). However, such open-field flexibility was by no means certain, and there is no satisfactory way of quantifying the production or consumption of the numerous new crops which were thus cultivated, nor whether they were always first introduced into the open-field system (Thirsk, 1997). For example, both woad and rapeseed (to name only two examples) seem generally to have been grown in areas of old enclosure outside the common fields. In the case of woad, in the Midlands generally but notably in Northamptonshire, it is not clear whether it was introduced into the open fields, rather than the woodland areas. Many parishes also had areas of enclosed land, usually under grass but sometimes in exhausting arable crops such as hemp, flax or hops (Mingay, 1984, p96). Economic considerations forced communities not only to consider new crops but also whether to alter the ratio of arable to grass. During the demographic quietus before 1750, and in the light of the stable or declining crop price profile it encountered and partly determined, there was a countervailing history of higher prices for meat and dairy products, as well as a rising industrial demand for wool and other raw materials derived from agriculture. The conjunction of these factors encouraged a move away from arable production towards grass (Jones, 1967, p8). With relatively stable contemporary wages in association with the decline in basic bread prices (as depicted in the wheat price trend in Table 11.1), the implied increase in purchasing power was spent by switching demand to animals and animal products, the prices of which held up throughout the period (Table 11.1). Grain prices recovered in the third and fourth quarters of the 18th century in response to the early effects of the demographic revolution which we date to this period. Yet adjustments in standards of living which we associate with the richer society that developed and which defied the Malthusian spectre, meant that dietary changes that were already in place could flourish. To that extent there was no reversal of the trend that was in place. In Table 11.1, in parenthesis, we rework the price trend to show that the terms of trade may have turned back towards grain but not sufficiently to dampen the enthusiasm for livestock products, the prices for which held up. The terms of trade between arable and pastoral products (wheat relative to butter, milk, beef and mutton in Table 11.1) did not move against pastoral products by 1790 (except butter), nor by 1806 and 1812 (again except for butter). Scholars' interpretations of the price inflation of this, the French wars period, had been mixed until Hueckel (1976) constructed a series of terms of trade indexes between arable and pastoral products. These more or less confirm the surge of demand for pastoral products that we also identify and to which we return below.

Transformations responding to domestic forces

Adjustments in the land use mix were not always in the gift of individuals in communally shared resources such as encountered in open-field agriculture. Instead, local courts of administration, the manor courts, circumscribed by ancient manorial procedures, still operated in the 18th century. According to Tate such control of the open fields and associated commons was never formally transferred from the manor and its courts to other local courts, though an act of 1773 devolved powers to manage the common fields to a three quarters majority in favour of the landowners. There are examples below which post-date 1773 and which suggest that the ceding of power away from the manorial courts was not everywhere recognized (Tate, 1969, pp258–267). Yet regardless of such niceties, it remained the case that the community in some shape or form had to decide on changes it wished to implement, and to accept the risks involved. If, for example, it agreed to abandon all or part of the mixed farming of the common fields in favour of permanent pasture, it had also to recognize the consequences on the ecological balance, the economic rewards, and the equity of resource use.

Agricultural communities across the Midlands responded to the economic considerations of the period post-1650 by a series of improvements. We are talking here about constant annual management rather than revolutionary change – changes that were 'unambitious and quite small in scale'. These consisted of the regulation of commons, partial enclosures, consolidation of scattered holdings, intakes of waste, and conversion of old arable land to grass and the breaking-up and improvement of ancient pastures (Mingay, 1984, p122).

The first adjustment within the open fields involved creating new grass or preserving existing grass resources. In the demographic conditions before the third quarter of the 18th century, with the economic or market attractiveness of pastoral products relative to grain products, there was mounting pressure put on grazing resources. This led to overgrazing of stock, which threatened to degrade the communal resources, the commons and the cow pastures. In compensation, parcels of land were laid down in temporary grass leys. Such convertible husbandry was already well established by the 16th century and by the 17th century the division of fields into arable and ley or grass-ground had become common (Beresford, 1949, p92; Hunt, 1957, p270; Hall, 1995, pp20–29, 157–164). It involved intermixing grass leys with the cropped lands or strips in the open fields. On farms owned by New College Oxford in Hempton in 1624, 24 per cent of the land was in grass leys, in Addlesbury in 1628 it was 16 per cent, and in Shutford in 1653 it was 34 per cent (Havinden, 1961, p74). Pasture shortages by the end of the 17th century led the commoners at Ibstock to convert two lands to grass leys for every yardland held in the Neather Field, specifically to augment the cow pasture (Leicestershire Archives, DE 390/56. A yardland was an old method of describing and crudely measuring an area of land but it varied in precise size even from parish to parish let alone from one county or broad district to another. A rule of thumb suggests that a yardland was about 30 acres or 12 hectares). At Grafton in Northamptonshire in the 1720s and 1730s it was proposed that no more than one-third of the land in the common fields should be under the plough and the rest in grass (Northamptonshire Archives, G3883). At Lubenham in Leicestershire in 1734 four tenants renting from Samuel Wright had on average 36 per cent of their open-field land in grass leys rather than arable crops (Leicestershire Archives, DE 2960).

One of the advantages of laying parcels of land down in temporary grass leys is that it improves biodiversity and helps to integrate livestock and crops in a balanced, ecologically sustainable manner. We say this not as a post-Brundtland analytical rationalization of an ancient system, but rather as a recognition that historians have clearly identified a custom and practice in operation that can now be presented in modern terms. Moreover, it stands in contrast to other agricultural systems which were more land abundant than England. We have in mind here the kind of settlement history in 19th-century North America where settlers moved on to new ground once they had exhausted the old ground since that was automatically a way of recovering biodiversity lost through soil exhaustion. In the meantime the exhausted ground took 20 or more years to recover through natural regenerative means. There was a limit to the extent to which such practices could prevail, a limit that was reached many generations ago in England. Instead convertible husbandry became the solution.

The second means of adjusting the terms of trade between crops and animals was through piecemeal enclosure of small areas of the open fields, usually in the period under study and for the geography we have identified, for conversion to permanent pasture. Typically this occurred at the edges of parishes remote from the core of arable activity, on land which because of its location may have been starved of manure and the very best husbandlike attention. These old enclosures ranged from bite-sized pieces to very extensive but mostly contiguous stretches of land (Thomas, 1933, p79; Swales, 1937, p245; Turner, 1980, pp137–141; Hall, 1995, p22). Many of these intakes from the communal lands probably began as arable ley grounds located at the fringes of the open fields or in reasonably compact blocks that did not interfere with the general farming of the arable field (Hoskins, 1957, pp160–164). Whatever their origin, these enclosures came to be managed outside the open-field system. At Hallaton, Leicestershire, in 1707, 36 per cent or 796 acres (322 hectares) of the village was enclosed in this fashion leaving the remainder open (Leicestershire Archives, DE 339/340). Out of 932 acres

(377 hectares) surveyed at Lubenham in 1734, 75 per cent was enclosed (Leicestershire Archives, DE 2960). At Laxton in Nottinghamshire from 1894 acres (767 hectares) which were once open fields, 1143 acres (463 hectares or 60 per cent) were still open in 1736 (Beckett, 1989, p317). Occasionally individual fields were removed from cultivation altogether. At Cotgrave in Nottinghamshire one of the four open fields was turned down to grass in 1717, and the others followed piecemeal until the enclosure legislation of the 1790s simply confirmed that the village was now almost entirely in pasture (Nottingham University Manuscripts Department, MaB). At Orston, also in Nottinghamshire, both in 1730 and in 1753 and piecemeal thereafter, there was conversion to permanent grass from the open-field arable to such an extent that by 1793 only 14 per cent remained in arable. This soon disappeared following the enclosure of that year (Barnes, 1997, pp125–132).

A third method that altered the balance of arable and grass was the enforcement or revision of agreements that restricted grazing rights. The owners of cottages and holdings had rights to graze a given number and type of animal on the commons, and on the crop stubbles after harvest. Permanent commons were usually on poor ground or waste, but that made it even more important that the correct stocking density was maintained with a mixture of types, ages and sexes of animal, to maximize the maintenance of a good grass sward. Though contemporaries were aware that grassland would benefit from careful management, nevertheless commons were often seriously neglected, and even encroached upon. In an attempt to control the situation at Cosgrove in Northamptonshire, the field orders of 1686 required that 'all those persons that have flocke or flockes upon the green or any other part of the commons or waste shall take them off by the first of February next' (Northamptonshire Archives, FS70/1). In Leicestershire, the Sheppy Magna manor court in the late 18th and early 19th century disallowed repeated encroachments on the communal wasteland, opened them up and returned them to communal use (Leicestershire Archives, DE 798/1; Turner, 1980, p143). Once the rules were enforced and unauthorized encroachments ended, the equitable access to agrarian resources was restored.

The enforcement of stinting agreements and field orders helped to maintain the integrity of the open-field farming system. New and revised agreements bemoaned the neglect and over-stocking that occurred by way of justifying amendments or the enforcement of new stints. Penalties were imposed for failure to comply with the rules, thus restating the importance attached to communal equity in the use of these common resources. Exceeding the agreed stints was effectively the theft of an inequitable share of the forage. At Wigston Magna in Leicestershire in 1707 after a number of disputes over rights to common grazing, it was agreed to reduce the cattle stint from eight to four beasts and the sheep stint from 40 to 24 (Hoskins, 1957, pp238–240). At Castle Donington, also in Leicestershire, grazing resources were in such short supply that in 1737 they were eaten off by early summer. In consequence the cow pasture stint was reduced by 25 per cent and the sheep stint by 50 per cent (Leicestershire Archives, DG8/24). The necessity of imposing stints was expressed by the preamble to their renewal in 1718 at Little Bowden in Northamptonshire, when both the cattle and sheep stints were reduced by a half (Northamptonshire Archives, TLB/84).

Such rules protected the common grazing on both the commons and the arable stubbles, but the frequency of their renewal is suggestive of the pressure to increase animal stocks. At Orston in Northamptonshire the manor court determined the stint annually (Barnes, 1997), and a similar task fell to the field reeve at Withern with Woodthorpe in Lincolnshire (Lincolnshire Archives, 199/1). In an attempt to keep track of the cattle in Billington in Bedfordshire each commoner was required to notify the teller in writing by the end of March of the number of cattle he was keeping on the common. This broke down in 1772 when it was found that '… the Commons and Commonable Fields … have been overcharged and burdened with too many cattle to the great injury and prejudice … etc'. In consequence the stint was reduced (Bedfordshire Archives, BO1326).

Many agreements specifically prohibited the use of the commons by anyone without grazing rights, a reminder that modern-day ideas regarding commons developed out of specific and relatively narrow land rights. The commoners at Cosgrove in Northamptonshire agreed in 1715 only to rent spare stints on the common land to fellow Cosgrove villagers and not to outsiders (Northamptonshire Archives, YZ7849). At Gilmorton in Leicestershire in 1722 the agreements stipulated that 'No one shall lett sell give or dispose of his sheep commons from the Feast of St Martin until Ladyday [to persons] not living in Gilmorton but can receive compensation of 1 1/2 d for every sheep common not stocked or stored if notice is given to the constable…' (Leicestershire Archives, DE66). This is akin to a public good where the definition of 'public' is more like what Pretty and Ward refer to in a modern setting as a 'club' good (Pretty and Ward, 2001, pp210, 221 note 2).

Two equity principles were most abused and thereby tested by stinting regulations and other field orders. The first was the time-honoured egalitarian principle that individuals should not keep more stock on the commons in the summer than they could reasonably feed on their own land in winter. Thus at Ibstock in Leicestershire in 1696 it was agreed that 'Field masters shall yearly once betwixt Lady Day and midsummer and once between midsummer and Michaelmas drive the fields and take an exact account of every mans stock that no person keep any more cattle than he have commons for in the common fields or pasture' (Leicestershire Archives, D E 390/56). The second was a clarification of the ownership and stewardship of common community resources. The common cause of tensions was the overstocking of the commons in the face of market pressures (widely discussed in Ault, 1954; Yelling, 1977, pp153–156; Turner, 1980, pp145–149). For the community to regulate itself in the face of such pressures, the local manorial and other courts had to be active, but their powers were gradually eroded more or less by the difficulty of policing the common property. Each time a parcel of land was removed from the communally administered system, everyone else's entitlement was adversely affected. The more this occurred the more occasions the local courts had to intervene, but also the more often their powers were questioned and sometimes ignored. In consequence the local court system collapsed or was forced to accede to local pressures, often because farmers were searching for ways to respond to everyday market forces. The courts were simply not equipped to counter the demand for economic individuality, which could often be achieved only through the formal and legal procedure of enclosure. Barnes has shown how the erosion of power exercised by local courts unfolded in the Nottinghamshire village of Orston (Barnes, 1997).

The Final Breakdown

We have stressed the capacity of open-field communities to react to pressures, whether of an ecological, economic or equitable nature, by adjusting farming and yet retaining sustainability. Yet in the longer term the open-field system collapsed. As a system it was, in modern terminology, unsustainable. It was possible to adjust the ecological balance, to lay down areas of arable to grass, to enclose areas of remote arable for permanent pasture, or to alter the stints on the commons, but the degree to which the system was completely flexible and therefore inviolable is open to question. The local ecology may have been firmly established but the system of managing it could not resist external economic considerations, particularly in the form of agricultural commercialization in the face of changing demand. Ultimately something more fundamental was needed, and this was to be enclosure and the parcellation of land into individual properties. At the same time it meant the extinction of common rights. At Wendover in Buckinghamshire in 1777 an act was secured to exchange land in the open fields to create a degree of consolidation of otherwise intermixed land ownership. This was not a full enclosure but rather a consolidation, but it did require the break-up of boundaries and access points between ownership strips and therefore the loss of scattered sheep pastures, since those boundary and access lands were usually grassed over. One of the local courts agreed to let clover and turnips be sown in place of the lost pasture. This arrangement proceeded smoothly for 12 years until one of the farmers turned a flock of sheep onto the clover in May before the agreed time for depasturing. The crop was lost, equity was challenged, and the parishioners proceeded to a formal enclosure through a parliamentary act (James and Malcolm, 1794, p29). This and countless examples like it, and also the variations of it that we have intimated, existed in the 17th and 18th centuries and are real-life examples of Hardin's theoretical 'tragedy of the commons' in which individual and collective utility are sometimes at odds with each other (Hardin, 1968, p1240).

In its purest form the open-field system was non-specialized and non-intensive. It was developed in a context of relative community self-sufficiency (which underpinned ecological, economic and equitable considerations). In saying this we recognize that the village was never entirely self-sufficient because taxes and rents left the community, market goods were bought in, and there were also significant commodity trades, for example in seeds. Nevertheless, it was fundamentally unsuited to and therefore unsustainable in the context of a market economy which emphasized the virtues of regional and local specialization. This is what emerged from the economic conditions of the century or so after 1650 and which in the midland counties of England tended to suit livestock farming and its end products ranging from meat and wool to milk. On the heavy clays of the English midlands the production of turnips, which was increasingly transforming light soil areas such as Norfolk, was inappropriate. In contrast, the increasingly developing exchange economy, which was underpinned by river navigation improvements, canals and turnpike roads, suggested the virtues of increased specialization which in the study area pointed to the advantages of a grass-based agricultural economy. From the 17th century, and probably even earlier in some parts, the pressure built up sufficiently to suggest that the adaptations to the system we have described were inadequate. Enclosure and the ending of common property rights in favour of separate and individual ownership became the order of the day. A rising tide of opinion from the 17th century onwards and culminating in Arthur Young's invective against open-field agriculture and the 'Goths and Vandals' who managed them in the 1760s and 1770s convincingly championed the benefits of farming in severalty (entirely private farming) (Mingay, 1975, p99). While the potential costs deterred (or at least deferred) enclosure, in the end market forces could not easily be resisted whatever the potential threat to the rural community (Mingay, 1984, pp96, 117).

In the light of the price trends we have discussed, pastoral farming made economic sense in the period leading up to the mid-18th century, especially on the heavy clays of the study area, the English midland counties. The pressure to convert to pasture inevitably increased the pressure to enclose (Turner, 1980, ch 6). Ecological issues also intruded, particularly the management of animals. Breed management could improve the productivity of a flock or herd by matching breed and use – for example by developing specialized cattle breeds for dairying, or by using early maturing animals in a feeding/fatting system. But communal grazing was a barrier to the improvement of livestock through selective breeding. In addition, disease control became increasingly important as the value of the stock increased, but this was difficult to undertake with communal grazing. We are uncertain of the extent to which communal regulations of stock density of the sort that we have already discussed were on their own sufficient to maintain the quality of stock, though we also have spasmodic indications of specific regulations that were introduced. For example, regulations were put in place at Mountsorrell in Leicestershire, specifically banning sheep with scab and infectious cattle from grazing on the commons (Leicestershire Archives, DE 40/46/3). Within the old system, any change in animal husbandry relied on the efforts of the entire community, including those with little interest in the new ways. Individuals had insufficient daily control of their animals to maintain standards that were relatively easy to achieve on enclosed farms. A system reliant on communal action was no longer sustainable. The shift towards specialized and more productive and intensive agriculture was outside the scope of a system originally established and developed to provide the needs of a largely self-sufficient community. It was not sustainable at the higher levels of productivity that could be reached by farming in severalty. The three principles in the sustainability model – ecology, economy and equity – sometimes pulled in opposing directions.

Farming in severalty facilitated changes of the sort that open-field agriculture could only introduce slowly and in piecemeal fashion. It was as if the remedies we have discussed above were remedial – meeting crises as and when – rather than inclusive of the changes in population and demand that required more decisive action. That decisive action became enclosure. The open fields were abandoned, not all at a rush, but over a long period, with definable peaks of activity. Our earlier discussion of the study area of contiguous counties indicates both the location and the intensity of enclosure, but it hides the fact that this enclosure took place in two waves of activity. There was a first intensive enclosure in the third quarter of the 18th century in which the trends towards more pastoral activity detectable for 100 years or so was intensified. There was then a lull in activity in the 1780s before a resurgence of enclosure in the 1790s and on to 1815 and a slowdown thereafter. Thus the dismantling of the open fields had been in full flow up to the 1780s and how long the system would have taken to disappear entirely we shall never know, because the whole process took a new turn in 1793 when Britain entered into what turned out to be more than 20 years of (almost) uninterrupted conflict with France.

Inevitably, for an island state, the first and most pressing question to arise concerned the security and adequacy of food supplies. This quest tended to compromise environmental stewardship and equitable access to resources. In the 1790s a conjunction of circumstances including bad harvests and the impact of the war produced an inflation of prices (Table 11.1) and this exposed the vulnerability of the national economy. In the years 1771–1793 inclusive, the price of wheat rose above 50 shillings per quarter in only 7 years, and at its worst reached 54.75 shillings in 1790. (There were eight bushels in a quarter, and a bushel weighs some 25kg.) In four other years it was at or below 40 shillings per quarter. It averaged 46.6 shillings per quarter from 1771 to 1789. But from 1794 to 1821 it was always above 50 shillings. In the 1790s it was 57.6 shillings, but for the whole duration of the war it averaged 80.6 shillings per quarter. At its wartime peak the price of wheat stood at 126.5 shillings per quarter in 1812, falling to 65 shillings in 1815 and 44 shillings in 1822. It was not until 1835 that the price of wheat reduced to a level (at 39 shillings per quarter) comparable to the level of the distant generation of the early 1760s (Mitchell and Deane, 1962, pp487–488; Clark, 2004). But this was not just an inflation of grain prices, because as Table 11.1 indicates the inflation was just as strong for animal-derived products. The conjunction of war and demography was very potent on price trends but the enclosures and agricultural improvements that ensued were complicated.

In these circumstances the long-term movement we have described towards converting arable land to grassland at first sight seems to fall foul of the new contemporary contrary pressures to raise arable output during the wartime conflict. Enclosures on the heavy clays of the midland counties continued to feed the desire for more animal products, perhaps not to the same degree as prevailed in earlier decades, but nonetheless the trend was not reversed. Instead, during the war the grain crises for a country now under siege were relieved by enclosure of a different sort. There was the enclosure of the lighter soils, of the sort that occurred on the East Yorkshire and Lincolnshire Wolds, which could benefit in a different way from farming in severalty – not for conversion to pasture but for intensification of the arable (Turner, 1984, pp16–23). There was also a reclamation of otherwise ill-used land, the commons and upland sheep walks, moors and mosses, all commonly called at the time 'wasteland'. There may not have been a plough-up campaign to rival the ones witnessed in 1916–1918 or 1939–1944, but there was certainly a good deal of Parliamentary rhetoric along such lines. In 1803 Sir John Sinclair, a Scottish MP and President of the Board of Agriculture, called for an attack on the commons and wastes, and not just the highland ones. 'Let us not be satisfied with the liberation of Egypt, or the subjugation of Malta, but let us subdue Finchley Common; let us conquer Hounslow Heath, let us compel Epping Forest to submit to the yoke of improvement' (Turner, 1984, p23). This was intervention by default, but clearly the message suggested that the ecological balance might need to be compromised for the wider equitable crisis, not in this case of the community, but of government and the nation state itself. Sir John and the champions of enclosure could not be sure of the long-term impact of enclosing land that was otherwise used for traditional moorland or commons economy. It may not have compared with the ecological damage imparted by the wartime plough-up of sheep walks in the 20th century, but whether they recognized it or not, contemporaries threatened ecological sustainability by their short-term actions. They can have had few ideas as to the potential long-term damage they were in danger of imposing by enclosing commons and waste and then ploughing them for grain, but in the French wars, as in the 20th-century world wars, sustainability was compromised for reasons of national security.

Contemporary estimates suggest that the wheat acreage could have grown from something less than 2 million acres (0.8 million hectares) in the 1790s, to about 2.4 million acres (0.97 million ha) in 1801, and to 3.2 million acres (1.3 million ha) in 1808 (Turner, 1981, pp299–301). We cannot rely too heavily on these figures as they were based on little more than informed guesses, but they point towards a rapid complement to the trend towards grass, which had not been stemmed by the growth of population and grain prices from the 1760s. Furthermore, with spiralling prices as an incentive the old principles of equity were easily abandoned. Almost invariably enclosure began by extinguishing common rights, a gesture which symbolized the move away from the communal and towards the individual. The local communal administration with its policy of upholding common rights, by-laws, stints and other restrictions was swept away on this tide of individuality. Once lines of engagement had been drawn to divide the property and adjudicate on property rights, it meant the end of the communal care. At times enclosure was as much about the clarification of those property rights as it was about productivity strategies.

Enclosure, whether for extending the grassland or for improving the arable, represented the end of the old order. It brought with it the self-contained, ring-fenced farm, which in turn posed a new threat to sustainability. While the community with its local courts controlled farming practice, it also held back the enterprise of the individual. Through the enclosure process itself local legal restrictions operated by the enclosure commissioners ensured that all farmers were fairly treated (Beckett et al, 1998), but after enclosure those same farmers came directly under the control of landlords. At that juncture between community control and landlord control there was in some places and at some times a breathing space in which the accumulated sustainable work of decades or even centuries was put severely at risk. This was no better summed up than by Thomas Davis, a noted contemporary observer of the interface between communal open-field farming and farming in severalty. He said that enclosures made a good farmer better, but a bad farmer worse (Davis, 1811, p46). He meant that the good farmers were already resource managers but within a communal straitjacket, in contrast to the potentially indolent or inefficient farmers who were protected from doing great damage by the collective action embodied in communal management. Left to their own devices, once collective action was removed at enclosure, these farmers lost the plot and their part of the farming environment suffered. Therefore for future agricultural sustainability it was vital that the responsibilities undertaken by the local courts were transferred to the landlord, or more pertinently to his land agent. It is probably not coincidental that the late 18th and early 19th centuries witnessed growing professionalization of estate management. This was symbolized by the emergence of the land agent who replaced the old manorial steward, who had often been a lawyer employed mainly to oversee the operation of the manorial court (Beckett, 1986, p144). All the while there is also the age-old debate over the damage done to a landless sector of society when access to common resources was taken away by this enclosure process (Pretty, 2002, pp29–32).

Summary and Conclusion – Transitions in English Agrarian History

If Brundtland is the key definition of sustainability then open-field farming appeared to meet the needs of succeeding generations without compromising those of future generations. It was ecologically balanced, the economic benefits maintained the rural community, and it provided a degree of equitable access to resources. At the same time it was susceptible to adjustment, allowing communities to alter the balance between arable and pasture to reflect the wider economic world. Changing demand conditions constantly impinged on the three-attribute model of ecology, economy and equity, but inbuilt elasticity allowed temporary and also some permanent adjustments to be made without unbalancing the whole system. But that could not go on forever. The nature of demand developed throughout society with a rise of commercialization in manufacturing, a greater circulation of money, an extension of markets, and a greater variation in the demand for food away from mere survival needs to something more varied. This encouraged agricultural specialization, placed severe strains on traditional open-field agriculture, induced questions and decisions about land use and land access on a big enough scale to threaten the conditions of equity in the community, as well as putting the ecological balance of resources at risk. The resulting removal of collective responsibility at enclosure shifted the burden for sustainability from the community to the individual.

Sustainability is always threatened by crises, and sometimes short-term compromises are necessary. But in the longer term contemporaries understood and acted on the basis that agriculture must be sustainable. They may not have used the same terminology, but they understood that farming had to meet the needs of any particular generation without compromising the ability of future rural generations to meet their own needs. This is not some pie in the sky romantic view of the past but a realistic and honest assessment of the workings of the rural village economy. When they looked to make changes they did so cautiously, ensuring at each stage that the economic demands on farming did not compromise the ecological and equity considerations too much. Only under the stress of war were such considerations shuffled to one side. There are surely echoes of the traditional collective rural village economy in modern approaches to biodiversity, sustainability and communities (a play on words deliberately employed from the title of O'Riordan and Stoll-Kleemann, 2003 and further elaborated by O'Riordan in his introduction and partial summary of subsequent chapters, especially pp16–26).

Three hundred years ago in England the organization of the open fields more or less ensured that resources were used in a manner which was self-evidently good for the wider environment and community. This has also been illustrated in analyses that have a modern contemporary agenda as well as a historical focus (Skipp, 1978; Pearce et al, 1989; Soule and Piper, 1992; Pretty, 1995; MAFF, 1998). Moreover, the language of collective action has been employed recently to illustrate in other countries and in recent times how equitable solutions in rural communities have met the needs of local development in a sustainable fashion (Pretty and Ward, 2001; and many of the examples in Uphoff, 2002). Our point is that the history of open-field farming in England, and no doubt also in much of western and northern Europe, probably provides a laboratory of similar experiences from which modern analysts might derive some well-developed but perhaps now forgotten solutions. In this context it should not stretch the imagination to suggest that there are lessons to be gained from this passage of history to apply to the recent past, or indeed for application to present and future societies. Communal and quasi 'public good' resources can be managed even against the mounting odds posed by demographic and other internal and external pressures (such as war) that impinge upon them. The New Institutional Economics approach to common or corporate ownership has opened up new avenues of investigation of those circumstances that have determined the development from common to private forms of ownership and governance (Ostrom, 1990; Baland et al, 1998; Radkau, 2003). What we have offered here is an empirical example of that development but in the context of the modern theory of sustainable resource management.

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12

Farmers' Extension Practice and Technology Adaptation: Agricultural Revolution in 17th–19th-Century Britain[1]

Jules Pretty

Introduction

In the late 20th century agriculture faces enormous challenges. Production in industrial and green revolution agriculture is now close to or above levels that can be sustained by the natural resource base. Yet the demand for food and non-food products will grow as populations expand, so further increasing the pressure on natural resources. Agriculture expands into hitherto uncultivated forests, grasslands and wetlands; degrades on-farm resources through erosive and environmentally damaging practices; and transfers some of the costs of production off the farm to other sectors of the environment and economy (Barbier, 1989; Pretty, 1990a; Conway and Pretty, 1991).

The prospects would appear to be bleak. The growing food requirements will have to be met, at least in part, through improvements to agriculture in the resource-poor regions of the world. But farming households in these regions have poor access to external resources in the form of credit and nutrient and pest control inputs, are poorly served by rural roads and other infrastructure, and are rarely adequately supported by research and extension services. Where extension does reach them, the approach has been to attempt the transfer of technologies proven to work on research stations rather than on farmers' fields. New technologies rarely spread beyond the large farmers, and the aggregate impact remains small (Mullen, 1989; Russell et al, 1989; Pretty, 1990b).

However, in recent years increasing numbers of agricultural development schemes or projects have demonstrated that agricultural production can be improved in resource-poor regions through the adoption of technologies that maximize the use

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of on farm resources provided that farming households themselves are fully involved in the generation of technologies, in their extension to other farmers, and in the experimental adaptation to local conditions (Jintrawet et al, 1985; Farrington and Martin, 1987; Chambers et al, 1989; Fujisaka, 1989; Bunch, 1990; Pretty, 1990b). In many locations, small revolutions in institutional support and farming practice are occurring. Returns to investment are rapid; the poor become better off and more secure; the region produces surpluses; and the country as a whole benefits.

Components of a revolution

Such a technical and biological revolution also occurred in rural Britain during the 17th to 19th centuries. During a period in which there was no government ministry of agriculture, no national agricultural research or extension institutions, no radio or television, no pesticides or inorganic fertilizers, and poor rural transport infrastructure, aggregate cereal and livestock production increased to unprecedented levels. In the 150 years after 1700, wheat production grew four fold, and barley and oats three fold; the numbers of cattle supplied to markets tripled and sheep doubled (Chartres, 1985; Holderness, 1989; Mingay, 1989; Beckett, 1990). This remarkable achievement was brought about in two ways: the extension, largely by farmers, of new technologies that intensified on-farm resource use; and the promotion of extensification by the conversion of common pastures and woodlands to private farming.

New crops offered diversified opportunities to farmers by allowing intensified use of land. Increased fodder supply meant more livestock and so increased supply of manures improved soil fertility. Selective breeding of livestock produced more efficient converters of feed to meat, so permitting slaughter at an earlier age and higher stocking rates. New labour-saving machinery released farmers from the labour-bottlenecks at cereal and hay harvests; and new tools and techniques improved the efficiency of seed sowing. Underfield drainage increased cropping options on marginal land; and irrigation of watermeadows increased the supply of fodder, particularly during the late winter shortage. Complementarities with urban and industrial growth – the British population tripled between 1700 and 1850 – also meant increased soil fertility as agriculture assimilated industrial and human wastes.

Coupled with this intensification were the dual enclosing processes of open-field conversion to private farming, and the enclosure of common property natural resources to produce more private farm land. Whether the former had an impact upon agricultural output is controversial; the latter, through the passing of more than 3500 Bills in Parliament, increased aggregate output as more than 650,000 hectares of woods, pastures, marshes and fens between 1730 and 1820 were enclosed (Jones, 1967). Both intensification and extensification resulted in a net benefit to the economy through growth in agricultural production – both yields per hectare and area under cereals roughly doubled between 1700 and 1850 (Turner, 1982, 1984; Overton, 1984a; Allen and O'Grada, 1988; Holderness, 1989; Beckett, 1990). But the costs attendant upon the two strategies differed. Intensification mostly used on-farm resources, absorbed industrial wastes, and did not damage the environment; extensification harmed the livelihoods of poor households by removing their rights and access to the common property resources on which they so heavily relied.

Views of innovation and adoption

Until the last two decades, orthodoxy has held that the British agricultural revolution began about 1760 and ended in the early 1800s (Ernle, 1912). Credit for progress was given to a few, now famous, innovators: Tull for his corn drill, Townshend for turnips, Coke for the Norfolk Four Course rotation, Bakewell for livestock breeding, and Young for promoting all of these. The conventional view is that, once exposed to these innovations, the majority of farmers adopted them and the revolution occurred. However, claims for innovation rapidly driving production growth have not survived scrutiny. Some have suggested that all improvements began by the 1580s, spread rapidly in the 1600s, and were completed by 1767 (Kerridge, 1967); whilst others suspect there was no major discontinuity, and that gradual change occurred throughout a period beginning at about 1600 and lasting to the 1840s, when further rapid change occurred as a result of increased use of external inputs (Overton 1984b; Thirsk, 1987).

What is now clear is that Tull, Townshend, Coke, Bakewell and Young were simply good popularizers rather than innovators. All 'their' innovations were being practised by some farmers 50–100 years before they were born (Table 12.1). The lasting fascination for 'inventors' has diverted attention away from the process of diffusion and adoption, and it remains to this day a heresy to many agricultural scientists to suggest that farmers have much to say in the process of technology generation, diffusion and adaptation (see Rhoades, 1989). Yet in the British agricultural revolution they were centrally involved in all three. Farmers made diffusion active rather

Table 12.1 *The first known dates of innovative technologies and techniques and the later popularizers associated with them*

Innovation	*First known*	*Popularizers and their lifespan*
Seed Drill	1600	Jethro Tull (1674–1741)
Turnips	Late 1500s	Charles 'Turnip' Townsend (1674–1738); Arthur Young (1741–1820)
Artifical 'Grasses' (including clovers, sainfoin, trefoil, lucerne, rye grass, rib grass, *etc*.)	1620–1640	Thomas Coke (1754–1842); Townshend; Young
Norfolk Four Course Rotation	late 1600s	Coke; Young
Selective Breeding of Livestock	late 1600s–1700s	Robert Bakewell (1725–1795)
Irrigated Watermeadows	late 1500s	Bakewell; Young

Sources: Bowie, 1987b; Donaldson, 1854; Gamier, 1896; Hartlib, 1646; Jones, 1967; Overton, 1985; Parker, 1975; Young, 1786 than passive through farmer-to-farmer extension mechanisms; and there is considerable evidence that technologies, once adopted, were the focus of experimentation so as to make the appropriate adaptations to suit local conditions.

Farmer-to-farmer Extension

Farmers spread technical knowledge through rural tours and surveys, publications, farmers' groups and societies, open days and informal training.

Farmer tours, visits and surveys

The first systematic attempt to survey farming practice in Britain was undertaken by the Royal Society in 1664. In order to investigate 'what is known and done already … and … what further improvements may be made in all the practice of husbandry', a questionnaire of some 50 open-ended enquiries was circulated to farmers throughout Britain (Lennard, 1932; Thirsk, 1985). Only 11 replies survive, and these describe the various ploughs in use; the uses of different mixtures of lime, marl, seasand, seaweed and manures for different soils; the many varieties of cereals; the use of clover, and the preference of farmers for using 'seed grown in a … soil … at least different from the nature of that ground where they intend to sow it' (Lennard, 1932).

A step forward from this academic exercise was for the principal investigators to make rural visits themselves. The 1700s were an age of global exploration and colonial expansion, and travel itself became a symbol of intellectual growth and moral discovery (Rogers, 1971). Travel became easier too, with improved roads, more comfortable coaches and improved supply of fresh horses at inns. However, even the fastest stagecoaches could travel at only 12–15km/hr, and the smaller parish roads were frequently impassable during winter and in wet conditions (de La Rochefoucauld, 1784; Addy, 1972). In the early part of the 1700s surveyors tended to focus on urban life, particularly the activities of the royal courts and aristocracy, but by the end of the century the focus had shifted to the countryside and to the method of surveying itself.

Daniel Defoe toured Britain in the 1720s and wrote of the economic and social conditions he observed (Defoe, 1724). Despite his eye for detail, his focus was at regional rather than farm level and he commonly missed local diversity; parts of Suffolk, for example, were 'applied chiefly to corn' or 'wholly employed in dairies'. In addition, his 'Tour through the Whole Island' was probably a compilation of visits made over many years – it lacks, for example, the detail about daily weather conditions that obsesses later tourers. In contrast, Samuel Johnson studied 'rural salt processing industries whilst his contemporaries studied castles' (Curley, 1976). Johnson insisted that to know life well, he had to see it first hand, regarding travel as essential 'to test the principles had from books' and to regulate 'the imagination by reality, and instead of thinking how things may be, to see them as they are'. Johnson toured Scotland with James Boswell in 1773, Wales in 1774 and made many other short tours that covered most of England (Johnson, 1775; Boswell, 1785; Curley, 1976).

But, despite their attention to reporting, neither Johnson nor Boswell were farmers. Farmers began to tour the country to observe and learn from other practitioners, and to record the practices and experiments they found. The principal objective of the rural investigation, as Arthur Young put it, was 'to display to one part of the kingdom the practice of the other … and to draw forth … spirited examples of good husbandry from obscurity' (Young, 1769).

The most renowned touring farmers were Young and William Cobbett. Young toured first as an individual interested in the activities of other farmers, and later as an official of the Board of Agriculture. Cobbett began his 'Rural Rides' the year after Young died. Both established durable reputations on the basis of the knowledge gathered on these tours. But they were not alone as touring farmers: the well documented include Robert Bakewell who toured for 2–3 months every year (Pawson, 1957); George Cully, who also often noted in his letters that his neighbours were away on tour to observe agricultural practice (Culley, 1790; MacDonald, 1977); Boys and Ellman, two Kentish farmers, who travelled 1100km in 27 days in eastern England observing livestock management and cropping practice (Boys and Ellman, 1793); the de La Rochefoucauld brothers who made short tours in Suffolk and Norfolk and longer ones in the Midlands and North (Scarfe, 1988), and Richardson, Redhead and Laing who toured Scotland and western England studying sheep (Richardson, 1793; Redhead and Laing, 1793).

As tours became more common attention turned to the approach used for touring, so as to improve learning. Tourers were sensitive to local conditions and the farmers themselves and cautious over claiming too much from their findings. Though Young travelled some 9700km in his first three tours, his concern over possible sampling biases made him cautious about the representativeness of his findings (Young, 1768, 1769, 1771). One condition of reading his reports was that the reader 'pardon the incorrectness of hasty letters; written from inns, farmhouses and cottages, with accuracy in nothing but the matter of my inquiries … You must not expect the authority of such a journey as mine to be equivalent to a general and comprehensive view of the whole island' (Young, 1769).

However, Young has been criticized for adopting conversational methods of research (Kerridge, in Overton, 1984a) and relying on 'mere opinion of the prejudiced' and the 'bare assertions of guarded, or perchance designing men' (Marshall, 1808, quoted in Allen and O'Grada, 1988). William Marshall asserted that the tourer gained only a transient view of rural life, understanding 'a few particulars of practice that may happen to be going on at *the time of his tour*' (his emphasis) (Marshall, 1818). Tourers were 'raw observers' unless they had a depth of practical knowledge of the area to be surveyed. He believed it was best to live with a well-informed farmer for at least a year, so as to 'minutely observe the living practice which surrounds him [the farmer]' (Marshall, 1818).

Young was, however, aware of the need to crosscheck by triangulating the information he gathered: 'I met with some farmers who gave me accounts too improbable to credit … but always repeated my enquiries upon those occasions' (Young, quoted in Allen and O'Grada, 1988). Young drew attention to the benefits of careful observation: 'I have seen many men, who view the farms of other people, apparently for no other purpose than to seek opportunity of talking of their own … You walk through a whole farm with such people, without their acquiring one idea … I was once with a party viewing a farm. Two gentlemen … were so diffuse in describing their own farms and management that it was with the greatest difficulty that poor Reynolds (the farmer) could gain the least attention. When … they went, I requested to go back to a crop of his turnip-rooted cabbage, which we had passed without notice, owing to the volubility with which I was so ill entertained. Various particulars I then gained, highly deserving attention. I afterwards met one of those gentlemen in London, and could not but smile at finding that he was perfectly ignorant even of the existence of the plant in question, of which he might have … been informed of every circumstance of its culture if he would for a few minutes, have given attention to the objects before him' (Young, 1793a).

William Cobbett was also determined to find out the 'real state' of the countryside. Writing after his first day's travel from London, his view of observations made from roads are clear. In spite of drizzling rain, he said: 'It is true that I could have gone to Uphusband by travelling only about 66 miles, and in the space of about eight hours. But, my object was, not to see the inns and turnpike-roads, but to see the *country*; to see the farmers at *home*, and to see the labourers *in the fields*; and to do this you must go either on foot or on horseback' (his emphases) (Cobbett, 1830). He travelled by horse along the lanes and paths, talking to people, stopping at cottages. He was aware that this behaviour was unconventional: 'They think you are mad if you express your wish to avoid turnpike roads … I have crossed nearly the whole country from the northwest to the southeast, without going 500 yards on a turnpike road, and, as nearly as I could do it, in a straight line' (Cobbett, 1830).

Bad weather did not stop these tourers from talking to farmers and labourers in the field, who could not themselves stop work just because of the rain. On a wet day in August, Cobbett recorded that 'I made not the least haste to get out of this rain. I stopped, here and there, as usual, and asked questions about the corn, the hops, and other things' (Cobbett, 1830). Young was also more concerned with learning from farmers than with physical comfort. On the last day of a short tour of Norfolk, one of his two French colleagues recorded that 'it rained so much that, to tell the truth, one could hardly think of agriculture' (de La Rochefoucauld, 1784). But Young stopped at the farm of Mr Toosey, took 'a hasty walk over his excellently cultivated farm', and recorded four pages of detailed findings – in which the weather was mentioned not once (Young, 1784a).

Professional surveyors

The professional surveyor also played an important role in the extension of new technologies. They were farmers employed periodically by landlords to survey tenants' farms in order to establish the conditions, or covenants, of the lease, calculate the financial equivalent of improvements made by tenants, and suggest appropriate rents. The method of surveying was 'to view every piece of the land contained in each farm' and record in detail all aspects of farming and land management (Sayer, 1747; Peak, 1799). Sometimes tenants were found to be in breach of covenants: Arthur Biddell recorded in the 1820s that the 'cropping of field 11 of Mr. Fuller's farm has been contrary to covenants and good husbandry', and that 'a large part of muck which remains on the farm should be laid on Field no 2' (Biddell, 1828). A valuation by Mr Utton of the estates of Sir Philip Broke said one farm was capable of considerable improvement as 'it lies extremely well for getting manure from Ipswich, but little or no advantage is taken of it' (Utton, 1848). By also applying marl and chalk, and adopting the four course system more cereals, turnips and artificial grasses could be grown, and so more livestock kept: 'Each farm could be greatly benefited by carrying more sheep.' The landlord was recommended to make arrangements to pay back a sum equivalent to those improvements made but not yet benefited from, so giving each tenant every 'inducement to … make all (the manures) he can' (Utton, 1848).

Sometimes these reports go further and recommend the tenant visit other farmers to observe the effect of their improvements. Another Suffolk surveyor, Mr Brolter, having recommended the use of clay, marl and ashes, also noted their use was common in the neighbourhood and that the farmer should look himself: 'these improvements would impart financial benefits, besides it would add to the beauty of the prospects from the house' (Brolter, 1790).

Books, magazines and newspapers

The results of many of these surveys were published in books and journals, so giving farmers elsewhere the opportunity to learn of advances. Farmers also had access to agricultural information in newspapers, magazines and pamphlets. The period of the agricultural revolution saw a remarkable increase in these sources of information: in the period 1550–1600 about 2–10 new books concerning agriculture were published per decade; by 1700 this had grown to 20–50, and by 1800 to 150–400 (Donaldson, 1854; Perkins, 1932; Canney and Knott, 1970; Sullivan, 1983).

The quality of writing changed too. Whereas in the 16th–17th centuries authors tended to offer maxims and advice (see for example, Tusser, 1557; Markham, 1631) or to be urban-based lawyers, merchants, court officials and academics (see Donaldson, 1854, *passim*), books came increasingly to be written by farmers and based upon first-hand observation and experience. The first author to record experiments was Adam Speed (1626), who discussed trials with clover, carrots, turnips and parsnips. In the 1640s Samuel Hartlib published the correspondence of farmers, recording their experiments and improvements with green manuring, lucerne, turnips, flax and clover (Hartlib, 1646; Thirsk, 1985). A Mr Buckner was studying a hundred varieties of grass, the Earl of Southampton the impact of planting thousands of fruit trees in hedges, and a Mr Middleton the keeping of mulberry trees, silkworms and the weaving of silk. The detailed records were of individual improvers who were neither writers nor sometimes even literate. As Joan Thirsk has put it 'at all times Hartlib was alert to recommend in his papers any names mentioned in his hearing of men and women who wrote nothing …, but were practical improvers' (Thirsk, 1985).

Some authors, such as Jethro Tull (1731), wrote to publicize their 'inventions', whilst others toured before they wrote: Edward Lisle (1757) visited farms in Wiltshire, Hampshire and Leicestershire to ask farmers and labourers questions on all aspects of farming practice, 'how to burn lime, how to improve meadows, what plough was best. He stopped farmers at work in the fields, and asked them why they did certain things; he experimented at home with the early sprouting of barley and oats, and so on' (Thirsk, 1985). Arthur Young published his first book in 1767. He was always comprehensive, documenting for example more than 500 experiments in the four volumes of the Farmers' Tour of 1769. He was criticized by some contemporary agricultural writers for including details of both successful and unsuccessful experiments (see Gazley, 1973). He maintained, though, that his books were better because they were founded upon experiments and journeys, and was critical of books that had 'only the inferior part of the experiments, that is the remarks and conclusions: so that we have only the author's reflections, instead of that authority which enabled him to reflect; and from which we might draw very different conclusions. Hence arises the difference … the experiment is truth itself, the author's conclusions, matters of opinion, which we may either agree to, or reject, according to our private notions' (Young, 1767). By the late 1700s standards were thus higher, the detail greater and books were treated more as basic references (Thirsk, 1985).

Another contribution to extension was the introduction of journals devoted entirely to the views and practices of fanners. The *Annals of Agriculture* appeared in 1784 and continued for 45 volumes until 1815. Although about a quarter of the articles were written by Young himself, the content ranges from reports of experiments, minutes of tours, details of observations, recommendations for new practices, and general discussion on the state of British agriculture and the countryside. This journal was soon followed by other national journals and periodicals, including the *Commercial and Agricultural Magazine* in 1799, the *Farmers Magazine* in 1800, *British Farmers' Magazine* in 1826, *Journal of Agriculture* in 1828, the *Mark Lane Express* in 1832, and the *Journal of the Royal Agricultural Society of England* in 1840 (Goddard, 1989). As the more practical and experiment-based style became increasingly popular, so farmers could more readily calculate whether an innovation might be relevant to their particular conditions.

However, the number of farmers directly reached by these books and journals may not have been large. The circulation of *Annals*, for example, was of the order of several hundred in the early days, rising later to a few thousand. The most successful book was *Young's Farmers' Kalendar*, which was issued in ten editions in his lifetime, the fifth selling out of 2000 copies within a few weeks of its issue in 1804 (Gazley, 1973). The best agricultural newspapers, though, had larger audiences, selling 4000–6000 issues weekly (Goddard, 1989). Local newspapers rarely covered innovations in detail, though the *Newcastle Courant*, for example, did record the release of ducks into turnip crops to control caterpillar pests, mint in haystacks to keep out mice, and intercropping radishes with turnips to reduce the impact of turnip fly, and carried advertisements for new machinery, new seeds and new drainage techniques (MacDonald, 1977).

Farmers' groups

Farmers' groups that transferred knowledge by word of mouth or by direct observation were even better than the printed word. These were first established in the 1720s, growing more common over the next century. Some were small with a local focus, others larger and acting at a national level. Most held regular meetings and occasional shows and fairs, and sought to encourage innovation by offering prizes. But the turnover was considerable. Those that tended to succeed were established by groups of local farmers themselves, rather than imposed by outsiders, or had access to outside financial or patronage support.

The earliest agricultural society in Europe was the Society of Improvers in the Knowledge of Agriculture in Scotland, established in 1723 (Ramsay, 1879; Handley, 1963). It distributed advice to members, such as on types of manures best suited to their soils, new crops and deep ploughing, but more importantly it encouraged each member to form small associations in their own districts for 'the diffusion of better methods of farming' (Handley, 1963). The East Lothian Society, for example, met monthly in a village inn, and grew to have 122 farmer members. The poet Allan Ramsay celebrated the vision of farmers' clubs by suggesting that improvements would lead to such an increase in productivity that rents could be tripled, 'without the purches of one acre more' (Withers, 1989). But the society closed after 20 years when a key figure in its success, Mr Maxwell, died. In 1754 the Edinburgh Society for the Encouragement of Arts, Sciences, Manufactures and Agriculture was established to offer premiums, or prizes, for good practice. In 1756 Mr Walker won the prize for 'the tenant who should produce the greatest variety of marls and other manures, with a short account of the places where they were found, and the uses to which they were applied' (Ramsay, 1879). But it closed in the mid 1760s. Societies were most insecure following the ill health, departure or death of a leading figure.

Two societies of national importance that did survive were the Society for the Encouragement of Arts, Manufactures and Commerce (later the Royal Society of Arts) and the Highland and Agriculture Society (HAS), established in 1754 and 1763 respectively. Both offered premiums for innovations, and took a systematic view of farming, in which the context of production and the circumstances of each farmer were central. Thus in 1772 the former offered prizes to determine the value of carrots, cabbages, turnips and potatoes for fattening livestock. Prizes encouraged experimentation, though they did not always resolve an issue. On sowing lucerne by broadcast or by drilling, Young commented 'as a sufficient number of experiments has not been published to prove which of these methods is most advantageous, the Society very judiciously leaves it to the cultivator's private judgement' (Young, 1767). The HAS may have been more effective in extension as it strongly promoted local associations. In Scotland 60 associations were established by members (Handley, 1963). Some were at village level: the Lunen & Vinney Farming Society of Dunnichen village was established by George Dempster, membership rose to 80, and the society brought yellow turnips and drilling of wheat to their locality. The final meeting was held in 1814, when Dempster was 80 years of age. The HAS itself survived because of the patronage of Sir John Sinclair, chairman of the Board of Agriculture, who gave them an annual grant of £800 per year, so helping them obtain a Royal Charter.

Local societies also grew rapidly in England. First were the Manchester, Norfolk, Bath & West and Sussex in the 1760s and 1770s, but by 1820 the total had grown to 50, and by 1840 to more than 400 (Goddard, 1989). The principal interest was again the award of prizes, usually at local shows and typically for new and/or high quality livestock, crops and machines. The Bath & West was particularly innovative, purchasing land to set up on-farm trials for new practices. During the 1830s Farmers' Clubs became popular in the promotion of improvements and diffusion of information (Fitzgerald, 1968; Goddard, 1989). These clubs held regular discussion meetings, established libraries and arranged visits to well-known farms.

The establishment of the Royal Agricultural Society of England (RASE) in 1838 marked the end of this agricultural revolution in internal resource use. As I shall discuss below, this society signalled the end of an era in which farmers' knowledge was accepted as best. From the 1840s, scientists off the farm gradually displaced farmers as technology generators, diffusers and experimenters.

Open days and fairs

Farmer groups also held occasional open days to publicize new farming practices and breeds of livestock. The most well-known meetings of this period were the 'sheep shearings' of the Duke of Bedford and Thomas Coke, at which there were often several hundred people present (Young, 1799, 1803, 1808). Of the 1799 open day at Bedford's Woburn farm, Young said 'it was the greatest meeting of the kind ever seen in England … A great assemblage of farmers, breeders and graziers from every part of the kingdom … in which the conversation was entirely agricultural' (Young, 1799). The open days at Coke's farm at Holkham ran annually between 1778 and 1821. Prizes were awarded for the best agricultural implements and livestock, information was exchanged on cultivation techniques and the performance of new crops, and ploughing matches were held. Farmers were also able to observe the practices on the estate, renowned for its rotation system that could feed 1500 sheep with no resort to permanent pastures or meadows.

Agricultural training

In a period that lacked formal agricultural training as well as extension institutions, farmers developed their own informal training networks. It was common, for example, for farmers to send their sons in their late teens or early twenties to spend a year in a progressive region (MacDonald, 1977). George Culley, an improving farmer and stockbreeder, frequently housed 8–10 students, and indicated in his letters that his neighbours did likewise (MacDonald, 1977). In some cases farm workers travelled to learn a specific technique – the first watermeadows in Northumberland were constructed on Culley's farm in the 1780s following a visit by one of his workers to George Boswell's farm in Dorset (MacDonald, 1977). Others learnt on the farm: a ploughman at Kelso who learnt how to drill turnips from his employer, who had himself spent 6 years in southern England, then spent 13 years as both ploughman and instructor of apprentices. When he leased his own farm he had an even greater impact on diffusion 'as a farmer paying rent, and acting at his own risk, had an immediate influence, as to the … rapid diffusion of turnip … husbandry among practical farmers' (MacDonald, 1977).

A government extension agency

Government agricultural policy was so dominated by promoting enclosure that little attention was paid to supporting farmer extension mechanisms. The Board of Agriculture, established in 1794, was charged with 'making every essential inquiry into the agricultural state, and the means of promoting the internal improvement' (Young, 1804), but despite Young being Secretary, it was underfunded and had too little support from government. It commissioned surveys for each county, but the surveyors were not necessarily farmers, and the results were patchy. Some were short and poorly written – only 38- and 34-page reports were produced for Shropshire and Rutland (Bishton, 1794; Crutchley, 1794), whilst others were much more comprehensive – 286 pages for Norfolk and 168 pages for Staffordshire (Kent, 1794; Pitt, 1794). New surveys were commissioned, but financial support to the surveyors and for publication was again inadequate. The Board closed in 1822, having succeeded only in sponsoring premiums and lectures, publishing articles and influencing government policy on taxes, weights and measures (Goddard, 1989).

Technology Adaptation

These extension mechanisms brought new knowledge to many more farmers. Yet knowledge of an innovation does not imply adoption. Farmers, once exposed to an innovation, still had to decide whether to adopt according to locally perceived incentives and constraints.

Incentives to adopt

The overriding incentives to adopt a new technology relate to the investment required and the perceived rate of return. An innovation requiring no new training or capital investment and bringing returns in the same season would be favoured over one that was costly, risky and producing benefits far in the future. Bringing quick returns for low investment were fodder crops, intensified rotation patterns and manures; livestock breeding was not costly, yet it could take time to produce the desired animal; but new machinery, drainage and irrigation required much greater investment.

Changes in prices could affect these perceptions. The increase in value of livestock products relative to cereals in the early 18th century favoured diversification, so increasing fodder and manure production (Beckett, 1990). Greater diversity on the farm also meant lower risk of complete harvest failure. But to adopt new technologies farmers required some security of tenure. Tenant right guaranteed them financial returns for the unexhausted improvements they made, but was only common in southeast and midland England. Thomas Moses, an improving and experimenting farmer of the 1820s–1840s in Lincolnshire, farmed on an annual lease with no covenants, except that he farmed 'in a tenant-like manner' (Beastall, 1978). To ensure he would receive full compensation on quitting the lease he recorded details of all improvements – repairs to farm buildings, stables, fences, ditches and roads; the purchases of ploughs and harrows; the planting of trees; and the establishment of a kitchen garden. Short leases, although a disincentive to invest when there was no tenant right, could easily be changed to account for new technological opportunities.

There was also a gradual change toward granting of long leases – Coke granted them for 7, 14 and 21 years so as to encourage investment. As James Caird, a later tourer, put it in 1852, 'the investment of a tenant's capital in land seldom contemplates an immediate return. He does not anticipate that a large expenditure in cleaning and enriching worn-out land will be all repaid to him in the first crop. He lays the foundation for a series of good crops, which in the aggregate he expects to repay him with interest If he drains, makes fences, or other improvements of a more permanent character, a still longer period is requisite to compensate him' (Caird, 1852).

It has been long assumed that the conversion of open fields to private property farming was in itself an added incentive to adoption of new technologies – potential improvers could not fight the inflexibility of collective decisions that stuck to tradition. But open fields did not necessarily prevent innovations, nor enclosure encourage them (see Havinden, 1961; Turner, 1986). Enclosure was not a direct incentive to improve, though it did allow for the rewriting of leases and raising of rents (Beckett, 1990). There remains widespread disagreement over whether productive gains occurred following enclosure – some have suggested output gains of 50–100 per cent (Wordie, 1983), others a modest 10–15 per cent (McCloskey, 1975), and others still that enclosed farms were no better than open (Allen and O'Grada, 1988).

Constraints to nationwide adoption

As I have described, there were commonly delays of 100–200 years between invention and widespread adoption. Technologies became common in restricted localities, but did not spread. Yet as rural Britain was so diverse such widespread coverage should not be expected. Kerridge and Thirsk have suggested there were 38 to 48 distinct farming zones in England and Wales, comprising mixtures of subsistence and market-oriented, pastoral, arable, dairying, special livestock enterprises, market gardening, meat rearing, woodland and pasture (Thirsk, 1987; Kerridge, 1967). Before passing from one zone to another technologies required widespread testing and adaptation. As Joan Thirsk put it 'new agricultural crops and methods could not find their niche within varied farming systems without undergoing a long process of trial and error that could involve many delays and setbacks' (Thirsk, 1987). But within zones diffusion could be slow if the improvement was costly or risky – after Culley established watermeadows on his farm it took 'near 20 years before any other person ventured to pursue the practice, and profit by the example. It is now beginning to spread in the neighborhood' (Bailey and Culley, 1805).

If agricultural labourers were against change, their unwillingness could put an end to innovation. This was particularly true for ploughs, drills or threshing machines that reduced or changed the labour requirement of workers who had spent years developing skills (Collins, 1969). New ploughs sent by Sir John Delaval to his estate did not meet with his ploughman's approval, who suggested the wood was twisted or green (MacDonald, 1977). But given the opportunity of observing the advantages of a new technology, adoption could be rapid. Reapers in Berwickshire in 1790 quickly adopted the scythe as a alternative to the sickle when they were outpaced by imported labourers (MacDonald, 1977).

Not all innovations succeeded in eventually being adopted nationwide. Dye crops, such as madder and woad, were experimented with in the 1600s, but did not spread as they represented too great a financial risk; tobacco was cultivated despite a government ban that aimed to encourage cultivation in Virginia, but it too died out, probably because it was too labour-intensive; liquorice was common around Pontefract and Worksop, but did not spread (Thirsk, 1985). The intervention by government in tobacco cultivation was rare – generally it neither directly supported nor hindered the adoption of new technologies.

Attitudes to experimentation

There is considerable evidence to indicate that farmers, once they adopted one of these new technologies, experimented to make the changes necessary for its adaptation to local conditions. They conducted field trials to test the efficacy of various manure and nutrient treatments on soils; they tested corn drills against other methods of seed sowing; they introduced new crops into rotations on some fields, whilst leaving others unchanged; they tested irrigated against dryland meadows; and they tested new methods of pest control. As Caird put it 'the detail is everywhere varied by the judicious agriculturalist to suit the necessities and advantages of the particular locality' (Caird, 1852). Farmers were concerned with integrating the results of experiments into their farm economies, and so analysed results to discover which were the most profitable options. To many, experiments were seen as a necessary part of farming. They did not expect to resolve issues once and for all, but rather saw them as part of an adaptive performance in the face of unpredictable climatic and market conditions (see Richards, 1989).

Many experiments were conducted first in kitchen gardens where they could be protected and monitored, and if successful then spread to the rest of the farm. In the 1780s a farmer discovered a single very productive ear of wheat in a hedge; he carefully cultivated it for four years in his garden, and by the mid-1790s this variety of 'Hedge Wheat' was said to be 'widespread and superior' (Goldhawk, 1795). The success of kitchen gardens as sites for experimentation was clear during the 1600s as commercial gardening grew rapidly to supply new vegetable and fruit crops to cities. London became surrounded by market gardens – their area growing from 4000 to 45,000 hectares between 1660 and 1720 (Thick, 1985). Innovative technologies and techniques were pioneered in gardens, such as row cropping of carrots, beans and peas to facilitate hoeing of weeds; new flower, fruit and tree crops brought from abroad; hot beds of still decomposing manure and compost put into long beds one metre high and broad for the cultivation of radishes, mushrooms, cucumber and asparagus; and the use of glass cloches to extend the growing season (Thick, 1985).

The practice of continuous experimentation was widespread, and the people who knew best how to conduct them were the farmers themselves. Farmer knowledge was recognized by de La Rochefoucauld on his visit to Suffolk: 'the knowledge which all these farmers possess is incredible – you must see them to realize how simple farmers can talk for an hour on the principles of their calling and on the reasons underlying their various forms of cultivation' (de La Rochefoucauld, 1784). Young said that 'experiment is the rational foundation of all useful knowledge: let everything be tried' (Young, 1767). He published *Experimental Agriculture* in 1770, comprising some 900 pages of detailed results of five years of experiments on 120 hectares of various soils. He had begun confidently expecting conclusive answers, but concluded the task in a different mood: 'I entered upon the following experiments with an ardent hope of reducing every doubtful point to certainty; and I finished them with the chagrin of but poorly answering my own expectations. Where I imagined 2 or 3 trials would have proved decisive, 40 have been conducted in vain' (Young, 1770). Bakewell's approach to experiment was openminded: 'I would recommend to you and others who have done me the credit of adopting my opinions to pursue it with unremitting zeal as far as shall be consistent with prudence and common sense, always open to conviction when anything better is advanced' (Bakewell, 1787, in Pawson, 1957). And Culley, in a letter in 1801, wrote 'I often say that we have a deal to learn yet. And every wise humble man will learn every year and every day' (MacDonald, 1977).

And yet these considered comments of farmers seem to have been very largely forgotten since the end of the agricultural revolution. They conflict with the predominant view of the agricultural experiment, namely that it is the domain of scientists and takes place solely on the research station or in the university. Orthodoxy holds that scientific agriculture began with the establishment of the RASE in 1838 and Rothamsted Experimental Station in 1843. These have brought immense benefits to agriculture, but have also served to hide the experimental practices of farmers. The result is now a deeply held belief that the first scientific experiments occurred only after the 1840s. A recent history of agricultural science in Britain begins at 1840 (Rossiter, 1975); and two earlier books by E. John Russell, a former director at Rothamsted, suggest that the 'first experiments' began in earnest at Rothamsted, before which any experiments were conducted by academics working alone. In neither of his books is the role of farmers mentioned (Russell, 1946, 1966).

Experiments to improve soil fertility

Experiments to improve and sustain soil fertility promised quick returns for relatively little investment, and farmers made use of both internal and external resources (Table 12.2). Some had been common for centuries – livestock manures, marling, leaf mould and lime certainly had long been crucial in maintaining soil fertility and physical structure (Pretty, 1990c). Some experiments were designed to test various treatments over time on the same field. Having grown nitrogen-fixing tares (vetch) before wheat and producing 'excellent crops' as a result, the Rev. Moseley of Drinkston felt that something further could be done in the three months between the vetch harvest and wheat sowing in order 'not only to keep the land clean, but to improve the succeeding crop' (Moseley, in Young, 1813a). He planted buckwheat (*Fagopyrum esculentum*) and ploughed it in as a green manure. The wheat benefitted, but as it was attacked by rodents on the threshing floor, he conducted the experiment again the following year. This time he harvested 3.3 tonnes from 2.4 hectares, a 'much larger crop than I expected'. Young commented that 'many have sown tares; and many have ploughed in buckwheat; and most have given a year to each; but it is the combination of the two that forms the merit … Mr Moseley in this husbandry is original' (Young, 1813a).

Other experiments were designed to compare the relative value of different treatments on the same field. In 1818, Arthur Biddell, a tenant farmer at Playford

Table 12.2 *Technologies for sustaining, restoring or improving soil fertility used during the agricultural revolution*

From within village community

- Livestock manure
- Green manure crops
- Seaweed, ploughed in green
- Nitrogen-fixing crops
- Compost heaps of weeds, rushes, bracken, old thatch
- Fish such as pre-rotted sticklebacks, pilchards, sprats
- Ashes
- Peat and turves
- Pond mud
- Soot
- Old clothing and footwear
- Leaf mould from woodlands
- Sand
- Pigeons' dung
- Fruit pulp
- Sawdust

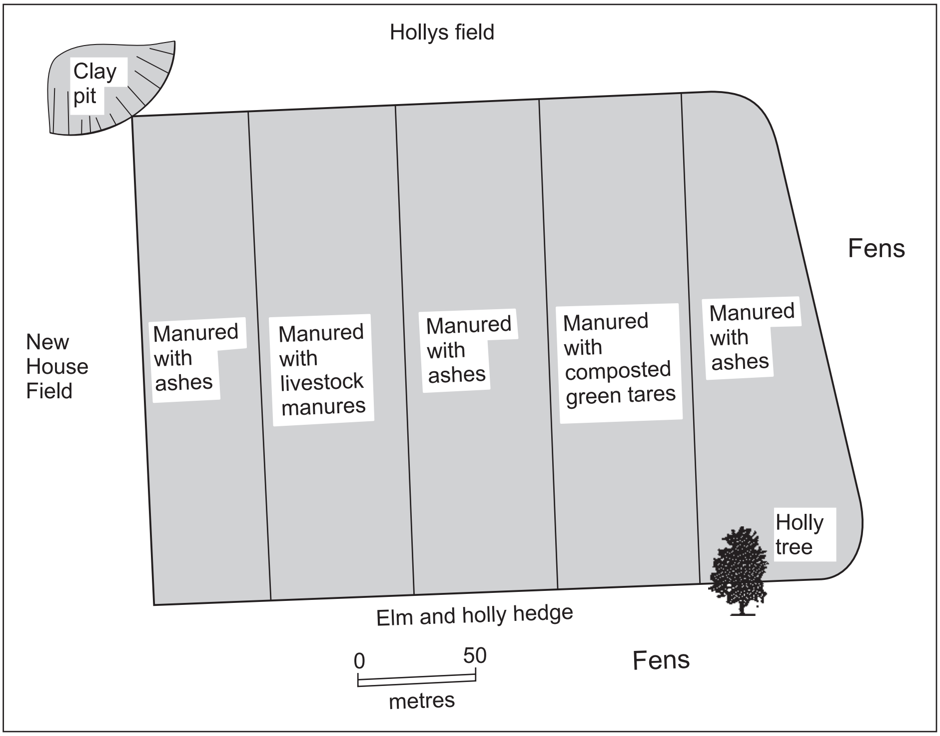
From outside village community

- Night soil from cities and towns
- Other refuse from cities and towns
- Industrial wastes, including pulverized slags, soap, ashes, waste bark from tanneries, shoddy from textile factories
- Oil cake (from crushed seed of coleseed)
- Bone meal

Sources: Mingay, 1977; Kerridge, 1967

in Suffolk, described an experiment on a wheat field divided into six small plots (Biddell, 1817–21). The plots were treated with 2lbs of salt, 1 bushel wood ashes, 1 bushel fine cinders, ammonia tar water and tar, and soap boiler's ashes, with a sixth control having no manure. Unfortunately there is no record of which treatment performed best, though he did record in another memo that all cereal harvested from experimental plots was taken to separate threshing sites so that yields could be measured and compared. In 1823 he described a complex experiment involving treatments for barley cultivation according to sowing method, manure type and freshness of the manure (Biddell, 1821–24). The treatment for each of the 13 sections of the field varied according to sowing technique (drilling or dibbling), manure freshness (straight from the stable door or exposed for a month), manure type (horse manure, sprats), and order of treatment (manuring first or sowing first). He indicated the 'best corn after the 70 bushels of sprats'. Figure 12.1 is a reproduction of another experiment to compare manuring with ashes, livestock manures and green manuring.

Some farmers experimented in order gradually to improve patchy quality fields. Thomas Moses's experimental approach on his Lincolnshire farm produced



Source: Arthur Biddell. *Day Book No. 2. 1817–1821*. ESCRO HA2/A3/2

Figure 12.1 *Experimental layout for wheat treated with ashes, livestock manure or composted green tares (vetch) grown on the four-hectare Holly Bush field on the farm of Arthur Biddell at Playford, Suffolk, 1819. Reproduced from Day Book No. 2.*

the best yields of cereals and turnips in the region having begun with some of the 'poorest pieces in the lordship' (Beastall, 1978). One field of 16 hectares was renowned for its heterogeneous soils – yields were generally poor, but varied widely across the field. He began by applying bones, ash, lime and manures in 1829, and then grazing it for two years; it was then partly underdrained and partly marled; by 1839 a good oat and wheat crop was recorded. In 1840 more marling, manuring and bones produced 'excellent turnips', the next year excellent barley and oats too. In 1843 the remainder of the field was underdrained and further marled. In 1845 the consistency of crops was now the same across the whole field, and in 1846 barley yielded at 3.5 tonnes/hectare.

Experiments with rotation patterns

Intensification advanced significantly with the introduction of root crops, including turnips, carrots, potatoes and swedes, and true and 'artificial' grass mixes, which included some 5–10 new grass species, nitrogen-fixing clovers, trefoils and sainfoin and burnet and rib grass.[2] The Norfolk Four Course rotation has become a classic model of intensification in the agricultural revolution. The introduction of roots and clovers permitted a change from spring cereal–winter cereal fallow to spring cereal–clover–winter cereal–root crops. Thus the proportion of land devoted to cereals declines from 66 per cent to 50 per cent, but for fodder crops it increases from zero to 50 per cent. But this idealized pattern was rarely adopted without some local experimentation and adaptation. On his 75-hectare farm Biddell continually changed the pattern to suit his needs. Sometimes it closely reflected the Four Course, as in Holly Bush field between 1807–17, but then an extra wheat crop is slipped in after beans in 1810 (Table 12.3). On Paddock field by comparison, wheat is grown in five out of seven years between 1807–13. In the second period the pattern is more varied, as an increasing number of crops are tested. In all he grew 28 different species of crops, with a maximum of 14 in any year. Of the introductions coleseed, flax, lucerne, sainfoin, hemp, wurzel, white and Swedish turnip, and Gold of Pleasure were grown for less than 3 years, and appear to have been rejected as unsuitable; whilst carrot, potato, tares, trefoil, red clover, radish, beetroot, rye grass, swede and mustard were absorbed into the rotation pattern (Biddell, no date). But despite this experimentation he did not greatly vary the proportion of land devoted to each of four classes of crop, namely cereals, roots, legumes and grasses plus miscellaneous vegetable and fibre crops.

This impression of local adaptation is further strengthened by the rotation patterns recorded elsewhere in Suffolk – in the County Report Young records 24 different variations in the Four Course rotation (Young, 1813a). Nonetheless, not all farmers were experimental. Two neighbours of Biddell's followed unvarying patterns: one rotated wheat-ley-barley-clover or beans, with an equal proportion of each crop on his 15 fields; and another kept to an unchanging Four Course pattern involving winter wheat–ley–spring cereal–legume, only very occasionally inserting a crop of peas or rye (Cooper, 1827; Pettite, 1830).

Not only did farmers experiment with the type of crops grown, they also carefully analysed profitability. Coke relied solely upon roots and artificial grasses to feed his sheep. Already convinced of the benefit of sainfoin, and wanting a replacement for red clover, he set aside a 12-hectare piece of land in the middle of a large clover and rye grass field to experiment with trefoil, white clover, cow grass, rib grass and burnet. In the first year Coke observed that the sheep voluntarily fed on the new crops. The first two trials were successful and by the third year he had extended the experiment to 90 hectares. Having observed the experiment Young said 'this is in truth doing justice to the new husbandry, by practising it with a spirit formed to establish it on the unerring dictates of experience' (Young, 1784a).

There were other experiments too. Bakewell repeated for several years an experiment to determine both the best fodder crop and method of harvesting. He sowed five strips in one field with rye grass, red clover, white clover, red/white clover mix and red clover/rye grass mix, and then overlaid these by mowing or grazing by cattle or sheep – the most productive treatment was mowing the red clover/rye grass mix (Pawson, 1957). And Young himself kept permanent experimental grounds

Table 12.3 *A Sample of crop rotation patterns on five fields of the farm of Arthur Biddell, Playford, Suffolk for the periods 1807–1817 and 1840–1850*

Years	*Fields*				
	Holly Bush	*Lollys*	*Paddock*	*Thistley*	*Church Field*
1807	Tu	W	W	Be	W
1808	B	Tu	W	W	B
1809	Cl	B	w	Tu	Lu/Ta
1810	W	Ta	Be	B	B/Be
1811	Tu	W	W	Cl	O
1812	B	T	Cl	W	Cl
1813	WCl	B	W	Be	W
1814	W	Cl	Ley	W	Pot/B
1815	Be	W	Cs	Tu	W
1816	W	Be	W	B	Lu/Be
1817	T	W	Tu/H	WC1	W
1840	W	Ley	Tf/Tu	W	Be
1841	Tu	W	B	Bt/Pot	W
1841	B	Tu	WCl	B	Tf/Tu
1843	Ta/Car	B	W	Be	W
1844	W	RCl	Bt/Car	W	RC1
1845	Bt	Rg	W	Tu	W
1846	B	Tu	Tf	B	Bt
1847	GP	B	W	RCl	W
1848	W	Be	Ta	W	Mus
1849	Tu	W	Mus	Tu	W
1850	B	Tu	W	B	Tu

Key:

W = wheat	Cs = coleseed
B = barley	Mus = mustard
Be = beans	GP = gold of pleasure (camelina)
Cl = clover	RCl = red clover
WCl = white clover	Tu = turnips
Luc = lucerne	Ta = tares
Bt = beet	Rg = rye grass
Tf = trefoil	Ley = summer ley
Car = carrot	H = hemp

Source: Biddell, no date. ESCRO HA2B3-4/1

on his farm. As the two touring farmers, Boys and Ellman, recorded in 1793, 'in Mr Young's experimental ground are several patches of about a perch each, of many sorts of grasses, amongst which the meadow fescue and *Alopecurus pratensis* seem the best; timothy tolerably good; peas bad; *Avena elatior* very strong but coarse' (Boys and Ellman, 1793).

It is rather surprising that given all this evidence of experiments with new crops there is relatively little on mixed or multiple cropping. The practice was certainly common in the Middle Ages, with cereals grown together with other cereals and/or legumes (Pretty, 1990c). Sometimes the mixtures were both more productive and less risky than the individual constituents of the mix. Yet limited evidence from early 18th-century probate inventories in Essex does indicate that about a third of all farmers chose to grow various mixes of barley, oats, peas and vetches (Steer, 1950).

Farmers did swap seeds to maintain genetic diversity. In Suffolk it was common for farmers on light sandy soils near the coast to swap seed corn with those on heavier soils of central Suffolk, thus avoiding merchants, who were suspected of mixing of seed stocks in their stores (Evans, 1960). In 1821 Biddell planted one field to wheat in four strips, the first with wheat from a Mr Fuller, then a Scotch variety from Mr Elys, the next to a North Country variety, and the last to 'wheat of my own growth' (Biddell, 1821–24). Later, in 1823, the wheat grown is his own, Scotch wheat from Mr Branson of Stromland, Kentish Red wheat from Mr Catlins of Battley Abbey, and another red variety from Mr Dicksons of Coddenham (Biddell, 1820–28).

Experiments with sowing techniques

Farmers also experimented with methods of seed sowing by comparing broadcasting the seed by hand, dibbling by making holes in the soil into which the requisite number of seeds were dropped, and drilling with newly invented seed drills. The amount of seed and spacing are important because if too little seed is sown then available water, nutrient and light resources are not fully used, and so can be captured by weed plants; but if too much seed is sown the crop plants then compete against each other, and though the weeds are suppressed yields also decline. The seed drill offered efficient weed control by evenly spacing the plants and so reducing seed requirement – for cereals to 5–15 per cent and turnips to 5–10 per cent of that for broadcast or dibbling (Wilkes, 1981).

The seed drill was invented in about 1600, and effective designs were patented by many farmers, including Bailey, Cooke, Tull, Young, Amos, Blaikie and Garrett (Wilkes, 1981). But technical shortcomings meant they diffused neither rapidly nor smoothly; there were problems with maintaining an even seed flow, balancing the strength of the machine against weight and the expense of production. Reports to the Board of Agriculture and in *Annals of Agriculture* suggest that drill husbandry was being widely experimented with at the end of the 18th century, but was only common in parts of Northumberland, Durham, Suffolk and Norfolk. There were still so few machines by the early 1800s that contract drillers became common – Suffolk farmers hired their drills with skilled labourers to farmers in Cumberland and Scotland (Wilkes, 1981).

During the agricultural revolution drilling was continually tested against the other techniques, all of which were often practised side by side on the same farm.

Table 12.4 *Results of experiments conducted on the farms of Thomas Coke of Holkham and Rev. Dr Hinton of Northwold, Norfolk, 1790s*

	Yield (kg/ha)	
	Drilled	*Broadcast*
Wheat (at Northwold)	2995	2620
Barley (at Holkham)	2360	2500

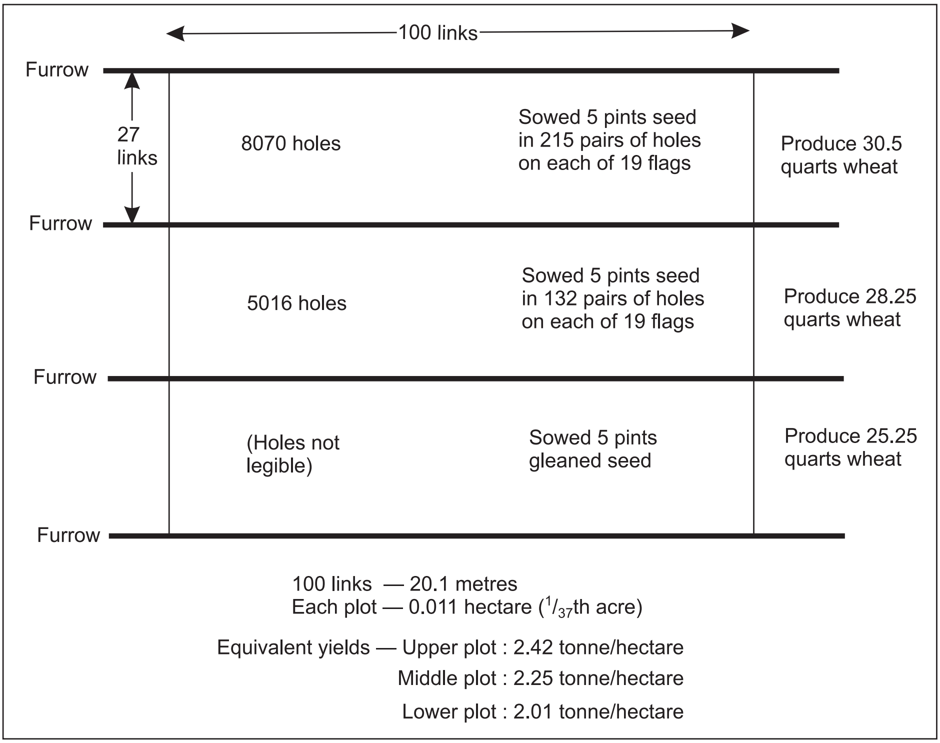
Source: Young, 1804

In the County Report for Norfolk, Young records the seed-sowing practices of 44 farmers by name; of whom 21 just drilled, one just broadcast, two just dibbled, and 20 were experimenting with combinations of the three (Young, 1804). The results of experiments varied according to local conditions and crops: for some broadcast was better, whereas for others drilling was best (Table 12.4). Mr Overman of Burnham Deepdale conducted his first drilling experiments with peas in 1790; then in the next year he compared the three techniques; finding the drill to yield 25 per cent more he then drilled all his peas and tried wheat for the first time in the third year (Young, 1804, 1793b). But drilling of barley and oats was not so successful: he tried, stopped, and then tried again.

Farmers also finely tuned each sowing technique. Biddell conducted an experiment to ascertain whether holes should be dibbled 'thick and seeds dropped thin, or holes thin and seeds dropped thick' (Biddell, 1812–16). As a diagram in his work book indicates more holes, each with fewer seeds, was the most productive treatment (Figure 12.2). And a Mr Harper ascertained the comparative benefits of the different sowing methods, including attendant weeding and other labour costs, by splitting a 4.5-hectare field into 8 strips, and conducting a different treatment for each (Figure 12.3).

Experiments with livestock breeding and management

At the same time as these new crops, rotation patterns and methods of sowing were increasing the production of on-farm forage, farmers also experimented with livestock breeding to produce animals capable of more efficient conversion of feed. Robert Bakewell, though not the first selective breeder, was the first to apply precise methods to produce early maturing meat-producing animals that would transmit these properties to offspring with certainty (Pawson, 1957). He aimed to 'fix the type' by establishing in his mind a clear picture of the desired animal. By inbreeding, selective culling, careful analysis of food consumption, conversion rates and carcass properties, he developed new breeds of cattle, sheep, pigs and horses. Selecting one or two traits he was able to make great advances, getting beasts to put on weight 'in roasting places, and not boiling places' (Pawson, 1957). But there were trade-offs: his cattle had long horns, and the sheep produced little milk and wool.



Source: Arthur Biddell. *Work Book No. 2. 1812–1816*. ESCRO HA2/B2/1B

Figure 12.2 *Experimental layout to ascertain whether wheat yields are better when 'holes thick and seeds thin' or vice versa. Part of Stock Hill Field, farm of Arthur Biddell at Playford, Suffolk, 1813. Previous crop was clover ley. Reproduced from Work Book No. 2.*

Although his farm was 180 hectares in size and supported 400 sheep, 150 cattle and 60 horses, it was too small to obtain verifiable results for his breeding. He therefore adopted a system of hiring out the best quality males for a season to other farmers, thus transferring genetic material to another herd. To begin with he was ridiculed, and the first ram commanded fees of only 16 shillings in 1760. But the demand for his animals grew as word spread of their attributes, and by 1784 his best rams were fetching a fee of £105 per season. Bakewell could now study the performance of the progeny of these males in herds and flocks of different genetic mixes. But to ensure that the replications were comparable he set strict conditions on each lease to ensure that feeding was natural and not forced. The effect of this system was to spread and extend new stock, whilst allowing him to conduct and monitor experiments on a nationwide scale.

But not all breeders were concerned solely with increased meat output. Sheep flock managers on the Wessex downs wanted economic feeding, mobile sheep that were good 'manure carriers' (Bowie, 1990). In this Hampshire Custom system of

18.5 metre strips

	Broadcast	Drilled with seed drill	Drilled by hand	Drilled plus dibbled up middle of rows	Dibbled in 3 rows, 1 grain per hole	Dibbled in 2 rows, 1 grain per hole	Dibbled, no rows	Dibbled, in 1 row, 4 grains per hole
Yield (tonne/hectare)	3.85	3.67	4.12	3.71	NR	3.51	3.23	3.09
Net return (£/hectare)	53.8	49.5	56.2	51.0	45.1	48.7	43.2	41.6

NR — Not recorded

Source: Mr Harper. 1806. Experiments in agriculture. *Annals of Agriculture* 44, 17–30

Figure 12.3 *Experimental layout of a 4.5-hectare field by Mr Harper of Kirkdale, Lancaster, to study the impact of different sowing treatments of wheat on yields and net returns, 1805*

management a rapid turnover of lambs was achieved through a system of internal resource maximization. Sheep travelled daily between pasture and arable fields, and were stocked at a rate of 1200 ewes and lambs per hectare at night. Early lambing in January–February based upon the early grass produced in watermeadows meant that fanners could market when prices were high. Rotations of sainfoin, leys, arable and fallow were locally adapted in an 'infinite number of variations and permutations' (Bowie, 1990). The sheep were shortwools, hardy and economic feeders, though not maximizers of meat. Flockmasters were continually experimenting with cross-breeding by bringing in rams from distant locations. William Humphrey, for example, hired Southdown rams from Cambridge, and produced large sheep with good flesh, and the strength and hardiness to consume root crops on cold hills (Bowie, 1987a). By comparison, sheep on the physically similar Wolds of Lincolnshire and East Yorkshire were relatively immobile longwools, yielding 3.5–5kg wool per fleece compared with 1.5–2.5kg for the shortwools (Bowie, 1990). Here farmers were oriented towards the rapidly developing northern markets, and relied heavily on external inputs and capital, buying bonemeal fertilizer in particular, and did not value sheep manures so highly.

Formal experiments to compare different breeds were also common. The Duke of Bedford compared four groups of 20 Southdown, Leicester, Worcester and Wiltshire sheep over 16 months by feeding them the same amounts of turnips and hay and, assuming the same grass consumption, found the weight gain best in the old breeds (Russell, 1986). Over a shorter period, Count Magzie of Silesia reported that sheep fed with potatoes over winter grew much better than those fed oats (Magzie, 1799). Russell has, however, suggested that the results of contemporary trials should be treated with caution, as design and execution varied widely (Russell, 1986).

Experiments with irrigation

A significant innovation of the agricultural revolution that improved internal resource use was irrigation. Water was diverted from streams and rivers to irrigate meadows, so producing spring growth some 4–6 weeks ahead of dryland meadows, a reliable hay crop in July, and further growth during the late summer. Although costs for surveying, design and construction were relatively high, the returns to investment were good (Bowie, 1987b). The value of the 'early bite' was central to the production of early lambs, and particularly to small farmers for whom 'even a small watermeadow which will produce an early crop of spring feed at the very time of the greatest pressure … must be more valuable to a poor arable farm than can be imagined' (Smith, 1806, quoted in Bowie, 1987b). Winter cereal yields also improved, as livestock were no longer fed off young cereal plants at this time. Hay production from good watermeadows was roughly double that of dryland meadows (Bowie, 1987b).

Bakewell experimented with irrigation to improve grass yields, constructing channels that eventually reached almost half of his farm, and then tested various 'proof pieces', as he called the treatments (Pawson, 1957). In one experiment he divided these into treatments with irrigation, no irrigation, irrigation plus manure, irrigation and no manure, spring water and stream water. He was proud that his livestock were fed exclusively on farm-produced fodder, and that he had invented a further use for these channels, namely the transport, or 'navigation', of turnips. At harvest, turnips were flung into the nearest channel and transported up to a mile distant, arriving clean and washed (Pawson, 1957). Other crops, such as carrots and potatoes, were put on specially constructed boats as they did not float.

Elsewhere, irrigation was valued for the suspended silt it brought. In eastern Lincolnshire, Yorkshire and Norfolk, water was directed into temporary enclosures, or warps, about 2 metres high and constructed from timber, earth or limestone. As the water drained away, so a 15–40cm layer of fertile silt remained (Beastall, 1978; Young, 1813b). The impact of warping on land value was significant, sandy soil improving from £12 to £150–250 per hectare (Beastall, 1978). With the addition of cattle and horse manures, warping fostered the local diversification of Lincolnshire agriculture to market gardening of carrots, onions, apples, peas, potatoes, flax, hemp and hops. Warping farmers also had ready access to transport to distant urban markets as they were close to large rivers.

As with all irrigation systems an ingredient of success is good community cooperation. Warps occasionally broke their banks and flooded neighbours' land; and watermeadows needed agreements before construction. In the Itchen Valley, for example, five farmers agreed not only the collective irrigation of 4.5 hectares of meadows, but also a quota for water allocation based on 7 days and nights each, and operation and management costs for them and their successors (Bowie, 1987b).

Experiments with drainage

Farmers also improved their land by experimenting with new methods for draining wet soils. The traditional method had been to plough ridges and furrows, but now farmers began to dig trenches that were filled with stones or plant matter, and to lay tile drains. In the 1820s James Smith of Perthshire, having laid a network of deep drains on 80 hectares, supplemented drainage with a heavy subsoil plough he had invented for the purpose (Watson and Hobbs, 1937). The land was converted from waterlogged to luxuriant, and 'farmers and landowners came crowding to visit' (Watson and Hobbs, 1937). Friends and neighbours in the Gargunnock Farmers' Club copied his method with considerable success.

Like irrigation, drainage so improved the value of land that incoming tenants were often willing to pay up to four times the former rent. But drainage did not advance significantly until the invention of a machine to make cylindrical pipes in the 1840s. Government then supported drainage by subsiding drainage costs by about 17 per cent between the 1840s and 1870s (Beckett, 1990).

Experiments with handtools

Another target for experimentation was the seasonal peak of labour demand during cereal and hay harvest. Inter-regional labour flows were necessary to meet this constraint, and harvest gangs in England were commonly drawn from Ireland and Scotland and the workforce in the newly industrializing centres, where iron furnaces, forges and mills often closed at harvest as workers returned to the fields (Collins, 1969; Jones, 1967). The opportunity to offset this constraint came with the development of new harvesting tools to replace the sickle. These were the scythe (blade attached to a bow or cradle to assist in the laying-down of the cut), the reap-hook (slightly heavier and broader than the sickle) and the bagging-hook (large, heavy smooth-edge hook with a second hook to tension the cereal), and represented a labour-saving potential of 40 per cent, 15 per cent and 35 per cent respectively (Collins, 1969). The adoption varied by location, and changes to blade and handle design were common.

Experiments with pest control

Diverse genetic stock, a diverse agricultural landscape, and multiple cropping would have checked outbreaks of pests and diseases during this period. But there were few explicit experiments on pest and disease control. Thomas Coke saved £60 worth of turnips in one field after he had gathered 400 ducks to control black canker caterpillars. 'In five days they cleared the whole most completely, marching … through the field on the hunt, eyeing the leaves on both sides with great care to devour every one they could see' (Young, 1784b). In Devon, a farmer wrote of the benefit of fumigating orchards with smoke to reduce pest damage (Gullett, 1786). More common was the treatment of seeds before sowing to reduce fungal or insect attack. In the 1780s, Young steeped wheat seed already black with fungi in various mixtures of water, lime water, wood ashes solution and arsenic and compared the number of smutty ears after a season (Young, 1788). Any treatment of more than 4 hours reduced infection to 1 per cent of that of water or no treatment. Later he describes the benefit of steeping turnip seed in water for 48 hours before sowing to reduce turnip fly damage (Young, 1813a).

Lessons for Sustainable Agricultural Revolutions

The successes and failures of the British agricultural revolution give some indications about the preconditions necessary for fostering sustainable agricultural revolutions today. Intensification of on-farm resources increases crop and livestock productivity, and so ensures that agriculture does not pollute or contaminate the environment (Pretty, 1990a; Conway and Pretty, 1991). Increased production based on internal resources increases the need for labour, and so increases the population-supporting capacity of the land. And more innovations mean more options for farmers to diversify, so reducing the risk of physical or economic shocks and stresses threatening their livelihoods. Most importantly, though, farmers fully involved in the process of technology generation, extension and experimental adaptation more readily make improvements. In the British agricultural revolution all this was achieved without explicit support from government.

At the same time, however, extensification was being strongly promoted even though it destroyed the common property resources that were essential buffers against adversity for those relying on the provisions of fuel, fodder, food and employment opportunities (Hardy, 1887; Collins, 1989; Jodha, 1991). During the agricultural revolution their value was barely recognized. They were called wastes, and represented to many a symbol of backwardness or underdevelopment. Young called those who opposed enclosure 'Goths and Vandals' (Gazley, 1973); John Smyth, a Gloucester landowner, said 'large commons and wastes burdened a village with beggarly cottages and idle people. They were better enclosed' (Thirsk, 1985); an Assistant Tithe Commissioner said that the heaths of Suffolk were 'mere sand encumbered with furze (*Ulex europeaus*) and fit for nothing but rabbits and sheepwalk' (Burrell, 1960); and Board of Agriculture reporters said common property resources were 'the trifling fruits of overstocked and ill-kept lands' (Humphries, 1990). But after enclosure poor farmers had to destock as fodder sources beyond their farms were no longer available and hay prices rose; and many farmers, given small plots of land in lieu of grazing rights, sold them to larger landowners, and 'the money was drank at the ale house' (Young, 1791, in Humphries, 1990). Generally those people living in diverse landscapes fared better than those in the monocropped cereal lands. Of the arable lands Cobbett said there were 'no hedges, no ditches, no commons, no grassy lanes … and the wretched labourer has not a stick of wood, and has not place for a pig or cow to graze. What a difference there is between the faces you see here, and the round, red faces that you see in the wealds and forests' (Cobbett, 1830). Extensification into uncultivated lands to improve aggregate food production should thus be treated with caution unless there has been full quantification of their economic value to poor people's livelihoods, and necessary steps taken to offset damage.

The success of intensification during the British agricultural revolution would appear to suggest three important strategies for agricultural development of resource-poor lands today:

1. reform of national and regional research, extension and planning to create a dialogue with farming households, with particular emphasis upon sensitive survey techniques to discover indigenous practices and the promotion of technology generation and adaptation by farmers themselves;
2. national and regional support to farmer-to-farmer extension mechanisms to increase the speed of diffusion;
3. adjustment of national pricing and subsidy policies to support the intensification of on-farm resources so as to increase productivity without damaging the natural resource base.

There do, however, remain many uncertainties. It is still unclear why delays of 100–200 years in diffusion occurred – particularly, what role did the invention of extension mechanisms play? It is also far from clear what role population increase played – did increasing population drive the need to increase food production, or did more people simply mean greater likelihood of passive diffusion? Most historical evidence of experimentation relates to larger tenant and landlord farmers – is this because only larger farmers can afford to take the risks attendant upon experiments and trials, or is the record biased because it is their documents that have survived to this day? To what extent, then, does the small farmer experiment? And lastly, to what extent did the benefits of intensification on resource-poor lands offset the damage caused by extensification and loss of common property resources? Answers to these and related questions would provide us with a more precise and better understanding of the invention, extension and adaptation processes underlying agricultural revolutions.

Notes

1 I am very grateful to E. J. T. Collins, Gavin Bowie, and Robert Rhoades, together with two anonymous referees, for their valuable comments and suggestions, and to Ken Smith for the illustrations.

2 The true grasses include rye grass (*Lolium perenne*), cocksfoot (*Dactylis glomerata*), timothy (*Phleum pratense*), meadow grasses (*Poa* spp.), meadow foxtail (*Alopecurus pratensis*), meadow fescue (*Festuca pratensis*); the artificial grasses were sainfoin (*Onobrychis viciifolia*), trefoil (*Medicago lupilina*), white clover (*Trifolium repens*), red clover (*T. repens*), cow grass (*T. alpestre*), rib grass (*Plantago lanceolata*) and burnet (*Poterium polygonum*).

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13

Past Successes

G. R. Conway

The Japanese have made the dwarfing of wheat an art. The wheat stalk seldom grows longer than 50 to 60 centimeters. The head is short but heavy. No matter how much manure is used, the plant will not grow taller; rather the length of the wheat head is increased. Even on the richest soils, the wheat plants never fall down.

US adviser to the Meiji government, 1873[1]

Without the Green Revolution, the numbers of poor and hungry today would be far greater. Thirty-five years ago, according to FAO, there were about 1 billion people in the developing countries who did not get enough to eat, equivalent to 50 per cent of the population, compared to the under 20 per cent today.[2] If the proportion had remained unchanged the hungry would be in excess of 2 billion – more than double the current number. The achievement of the Green Revolution was to deliver annual increases in food production which more than kept pace with population growth.

Many factors contributed to this success story, but of central importance was the application of modern science and technology to the task of getting crops to yield more. Cereal yields, total cereal production and total food production in the developing countries all more than doubled between 1960 and 1985. Over the same period their population grew by about 75 per cent. As a result, the average daily calorie supply in the developing countries increased by a quarter, from under 2000 calories per person in the early 1960s to about 2500 in the mid-80s, of which 1500 was provided by cereals (Figure 13.1).[3]

The history of the Green Revolution is well known, but is worth recounting here as a reminder of the power and limitations of innovative technology, and the crucial importance to its success of the economic, social and institutional environment within which it has to operate.

A careful analysis of the trends in agricultural productivity in a variety of countries, both developed and developing, suggests there is a point in history when yields begin to take off.[4] While agricultural production remains based on tradi-

Reprinted from Conway G R. 1997. Past successes. Chapter 4, in *The Doubly Green Revolution*. Penguin, London, pp44–65.

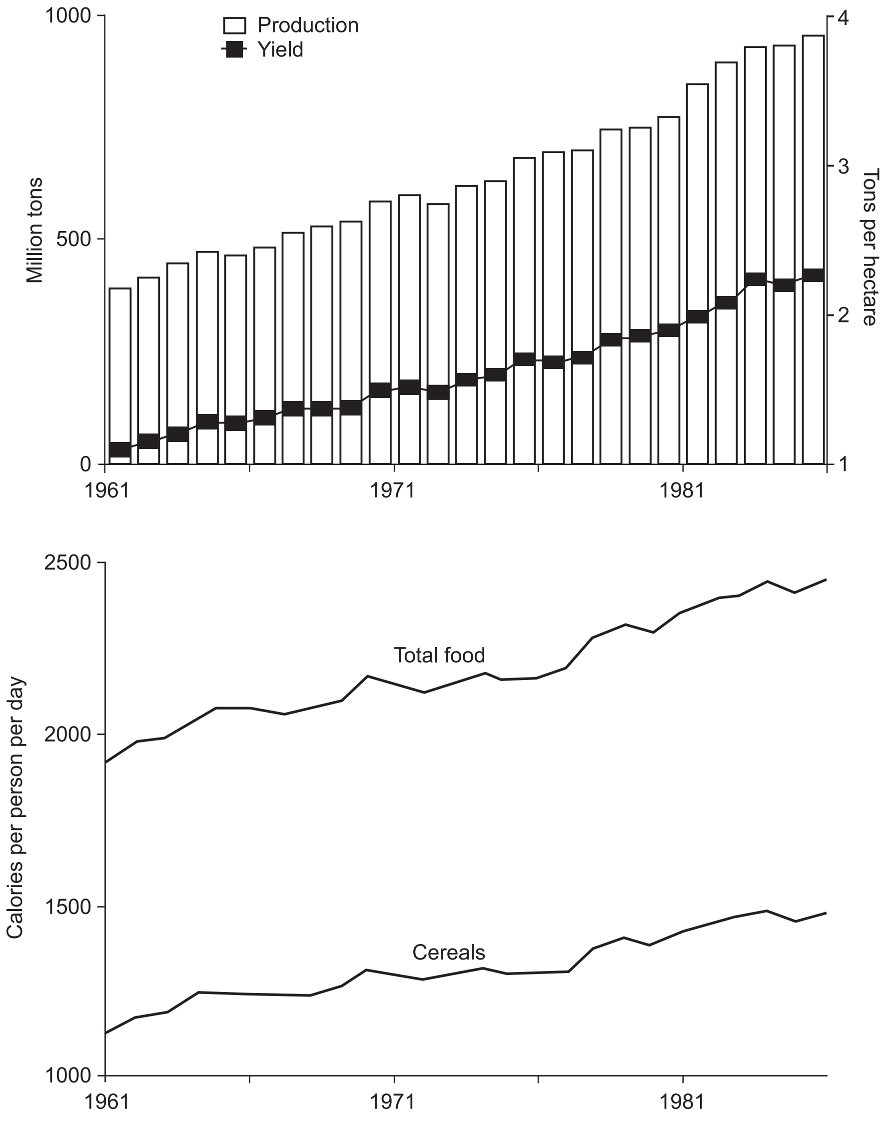


Figure 13.1 *Cereal production, cereal yields and calorie supply in the developing countries, 1961–1986*

tional practices, with fewer or no outside inputs, yield gains are modest, of the order of 1 per cent or less per annum. Production grows, barely perceptibly and largely as a result of increases in cropped area, until a critical threshold is reached when a transition to a new basis for production occurs. Much-improved varieties appear, farmers turn to inorganic fertilizers and synthetic pesticides, invest in irrigation and drainage and adopt a range of other new technologies, including the purchase of agricultural machinery.

From their analyses, Cornelius de Wit and his colleagues of the University of Wageningen in the Netherlands conclude this transition occurs when cereal yields reach about 1700kg/ha. Below the take-off point yield increases are of the order of 17kg/ha per year; afterwards they are 50–85kg/ha. There are, of course, exceptions: some countries (China is an example) experienced take-off from much lower yield levels, others, such as Britain and Japan, produced several spurts of growth with relatively low rates in between. Selection of indigenous rice varieties in Japan, coupled with increased irrigation, resulted in a yield increase between the 1880s and the First World War of about 40kg/ha per year.[5] Yields grew more slowly between the wars and then took off again after the Second World War, with annual yield growth of 75kg/ha per year.

In most developed countries the take-offs occurred soon after the end of the Second World War. High-yielding varieties, new fertilizer formulations and more effective pesticides came on the market, together with machinery that permitted more timely agricultural operations. Economic incentives, which included guaranteed prices, deficiency payments and other forms of subsidy, made sure the new technologies were widely adopted. Thereafter, growth in production was nearly entirely due to yield increase; in most developed countries the cropped area has declined since 1950.

The take-offs in the developing countries mostly occurred at the end of the 1960s as the new varieties produced by the Green Revolution began to be widely adopted. William Gaud, the administrator of USAID, first coined the name 'Green Revolution'.[6] At the time it was an appropriate description of a momentous event. Today 'Green' signifies the environment; then the image it conveyed was of a world covered with luxuriant and productive crops – the green swathes of young wheat- and ricefields. It was truly also a revolution in the scale of the transformation it achieved although, as we shall see, it did not go nearly far enough.

The origins of the revolution lay in a joint venture, the Office of Special Studies, established by the Mexican Ministry of Agriculture and the Rockefeller Foundation in 1943.[7] At the time, Mexican grain yields were very low, maize averaging about a quarter of US yields and wheat yielding less than 800kg/ha, even though most of the wheatland was irrigated. The Office was headed by George Harrar, with Edwin Wellhausen, a maize breeder, Norman Borlaug, a plant pathologist, and William Colwell, a soil scientist. Eventually the office was to have 21 US and 100 Mexican scientists, mostly working at an experiment station at Chapingo on the rain-fed central plateau. Its remit was to improve the yields of the basic food crops, maize, wheat and beans.

The research programme concentrated first on maize, the mainstay of the Mexican diet, consumed in the form of the thin, flat, unleavened bread called the tortilla. Mexican agronomists had already discovered that most strains of maize grown in the US were not well adapted to Mexican conditions, so the programme set out to try to duplicate the US achievement of breeding high-yielding, hybrid maizes but using indigenous varieties as a basis. Maize is a cross-pollinating crop, so that the seed collected by the farmer from his or her crop at the end of the season is usually highly variable. More uniform and higher-yielding hybrids can be created by deliberately crossing two distinct lines which have been inbred through several generations by self-pollination. The resulting hybrids combine the best features of both lines and usually have added a certain hybrid vigour.[8] At the time the Mexican programme began, about half of the cornland in the US was planted to hybrids. However, the disadvantage of hybrids is that new seed for each season has to be produced by repeating the cross, since the seed gathered at the end of the season from the hybrid crop will have lost the hybrid vigour and become contaminated. An alternative approach, adopted by Edwin Wellhausen, was to grow four or more inbred lines in an isolated field and let them cross naturally. These so-called 'synthetics' yielded better than the best existing varieties by 10–25 per cent and the farmers could simply save seed from their best plants from year to year.[9]

Success came very quickly. In 1948 1400 tons of seed of the improved maize varieties were planted. The new seed, good weather that season and the ready availability of fertilizer resulted in a record harvest and, for the first time since the revolution of 1910, Mexico had no need of imports. By the 1960s over one-third of Mexico's maizeland was being planted to new high-yielding varieties and maize yields were averaging over 1000kg per hectare. Total production had increased from 2 to 6 million tons.

Although maize was the main staple crop, Mexico was importing about a quarter of a million tons of wheat per year. Yields were very poor – 'most varieties were a hodge-podge of many different types, tall and short, bearded and beardless, early ripening and late ripening. Fields usually ripened so unevenly that it was impossible to harvest them at one time without losing too much over-ripe grain or including too much under-ripe grain in the harvest.'[10] In northern and central Mexico the soils had lost most of their fertility. On the newer, well-irrigated lands in the Pacific north-west the soil was generally fertile enough to produce high yields but stem rust was very destructive. Epidemics in three consecutive years, 1939–1941, in Sonora had caused many farmers to reduce their wheatland or stop growing the crop altogether.

The wheat programme, under the direction of Norman Borlaug, began by testing over 700 native and imported wheat varieties for rust resistance.[11] While some of the imported varieties were both more resistant to rust and higher yielding than the Mexican varieties, they had the disadvantage of late ripening. They needed the longer days of the northern summers to mature. But by crossing the imports with the best Mexican varieties, Borlaug produced, in 1949, four rust-resistant varieties each adapted to a particular ecological region of Mexico. Wheat is a self-pollinating crop, so that crosses have to be made by hand, but once made the new varieties will breed true and farmers can use their harvested seed for the next year's crop. By 1951 the new varieties were being grown on 70 per cent of the total wheatland and, five years later, Mexico was producing over a million tons of wheat, with an average national yield of 1300kg/ha. Imports of foreign wheat were no longer required.

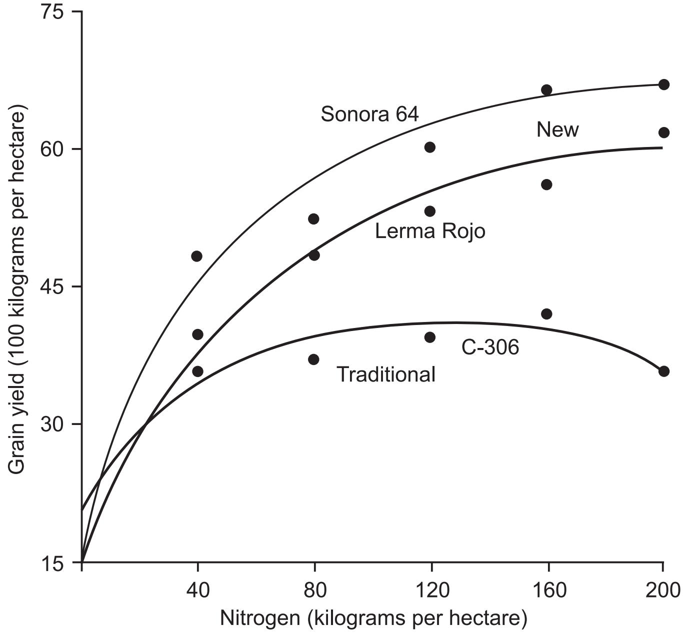
The next step in the wheat programme was to improve yields through greater use of fertilizers. Experiments on properly irrigated soils showed that 140kg/ha of nitrogen raised yields more than fourfold. Even on rain-fed soils, yields more than doubled and the addition of phosphate produced five- or sixfold increases. But the traditional varieties had a tendency to grow tall and lodge, that is they fell down under the weight of the luxuriant green growth produced by the extra nutrient uptake, in effect making the grain liable to rot and be less harvestable. The breeders also recognized the need for non-shattering varieties that would hold the grains until they were ripe enough for mechanized harvesting and threshing. And wheats with better milling and baking quality were required, now that Mexico was relying solely on its own wheats and not blending with the stronger, imported varieties.

As the quotation at the beginning of this chapter testifies, short-strawed varieties had long existed in Japan. In 1935 the Japanese had produced a new dwarf, Norin 10, by crossing one of their traditional dwarfs with Mediterranean and Russian varieties imported from the US.[12] This was spotted by a US agricultural officer working in Japan in 1946 and seeds were sent to Washington State University. Initially the crosses with US wheats resulted in sterile offspring but then a fertile cross was made from which, ten years later, Orville Vogel, of the US Department of Agriculture (USDA), produced a new semi-dwarf variety called Gaines that yielded a world record of over 14 tons/ha.

Norman Borlaug heard of Vogel's work and in 1953 obtained some of his early breeding material to cross with traditional Mexican varieties. By growing two crops a year, a summer crop at Chapingo and a winter crop at a second experimental station in the state of Sonora, lying in the rich, irrigated plain of the Pacific northwest of Mexico, he produced, in record time, two new, superior dwarf-wheat varieties. These were adapted to a wide range of day-length and other environmental factors, and highly responsive to fertilizer applications (Figure 13.2). By 1966 the new varieties were yielding 7 tons/ha. A decade later, virtually all of Mexico's wheatland was under these varieties and the country's average yield was close to 3 tons/ha, having quadrupled since 1950 (Figure 13.3). By 1985 total production had increased to 5·5 million tons.

Following the success of the new wheat and maize varieties in Latin America, attention turned to the needs of Asia. Over much of Asia the staple diet was, and still is, rice. Unlike wheat, rice is mostly grown by smallholders (on farms of less than 3ha) for home consumption. In the 1950s, over 90 per cent of the rice produced in the world was grown in Asia; national yields averaged between 800 and 1900kg/ha.[13]

Early in this century, Japan, China and Taiwan had developed a number of new rice varieties which had led to significant increases in production, but the major impact on Asian rice yields came in the 1960s as a result of the skilful efforts of two groups of breeders, working in ignorance of each other, in China and the Philippines. The benefits of scientists being able to pursue clear goals in multidisciplinary teams had convinced those involved in the Mexican programme of the need to create purpose-built research institutes which would attract scientists of the highest calibre. In 1961 the International Rice Research Institute (IRRI) was established at Los Baños in the Philippine province of Luzon as a joint venture



Source: B. C. Wright, 1972, Critical requirements of new dwarf wheat for maximum production, in *Proceedings of the Second FAO/Rockefeller Foundation International Seminar on Wheat Improvement and Production, March 1968*, Beirut, Ford Foundation

Figure 13.2 *Responses of new and traditional wheats to fertilizers*

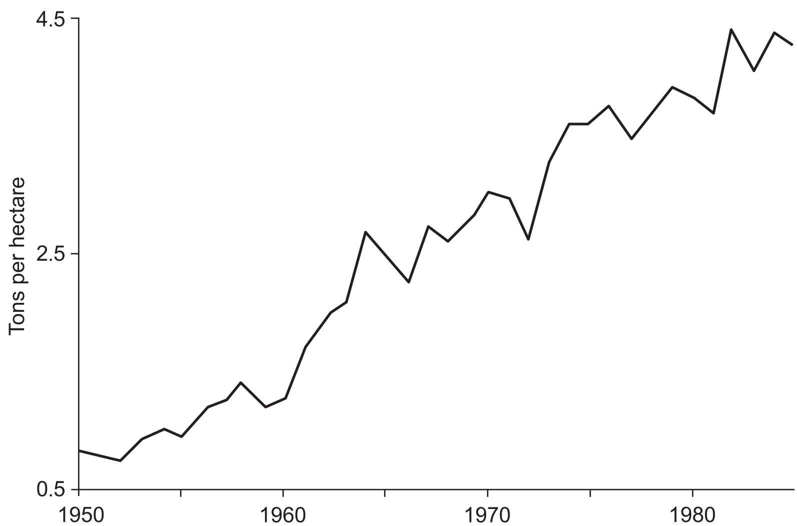


Figure 13.3 *Growth in wheat yields in Mexico*

between the Philippine government and the Ford and Rockefeller Foundations. This was the first of a family of new research institutes equipped with first-class laboratories and adjoining experimental plots located on good, irrigated land.[14] Excellent living conditions and international salaries added to the ability to attract the best scientists from around the world.

The Ford Foundation became a partner partly because its community development programme in India, started in 1951, had underlined the importance of agricultural research. The programme, largely run by social scientists, had assumed that improved technology was readily available and needed only a programme of vigorous education for it to be implemented. However, the village extension workers often proved inexperienced in agriculture and, more important, encouragement of increased fertilizer use turned out to be ineffective because the traditional cereal varieties lodged. Forrest Hill, an agricultural economist and vice-president of the foundation, concluded that the foundation had 'got the cart before the horse'. What was needed, he believed, was innovative agricultural research to support the extension work.

The first director of IRRI was Robert Chandler. He assembled a team of rice experts drawn from the US, India, Japan, Taiwan, Ceylon and the Philippines.[15] Experience in Mexico with the wheat programme and the knowledge already obtained from breeding programmes in India provided a blueprint for the new rices that were required (Box 13.1). A large collection of rice types was quickly

Box 13.1 *A blueprint for the new rice varieties*

A short, stiff stem (90–110cm), giving resistance to lodging

Erect, narrow leaves, resulting in increased efficiency of sunlight utilization

High tillering and a grain to straw ratio of 1:1, producing high fertilizer responsiveness

Time of flowering insensitive to day-length, giving flexibility in planting date and location

Early maturity (less than 130 days), giving increased output per hectare per day

Resistance to the most serious pests and diseases: stem borer and rice blast

Wide adaptability in Asia

Highly nutritious, with a high protein content and a better balance of amino acids

High palatability

Source: Stakman et al, 1967 (n. 7) and Barker et al, 1985 (n. 13) amassed at Los Baños and of the crosses made in 1962, a particularly promising combination was between the tall, vigorous variety Peta from Indonesia and Dee-geo-woo-gen, a short, stiff-strawed variety from Taiwan which contained a single recessive gene for dwarfing. In 1966 the new variety, named IR8, was released for commercial planting in the Philippines. It was immediately successful and, amid considerable publicity, was dubbed the 'miracle rice'.

In parallel with the work at IRRI a very similar breeding programme had been launched at the Academy of Agricultural Sciences in the Chinese province of Guandong.[16] Although this was only known much later, the Chinese and Philippine teams were using breeding material containing the same dwarfing gene – the Taiwanese variety Dee-geo-woo-gen had probably originated in southern China. In 1959 the Chinese produced their first successful cross, similar in many respects to IR8, and known as Guang-chai-ai. It was rapidly taken up in the province of Guandong and in Jiangsu, Hunan and Fujian. By 1965, a year prior to the release of IR8, it was being grown on 3·3 million hectares.

IR8 combined the seedling vigour of Peta with the short straw of Dee-geo-woo-gen. It was, like the new wheats bred in Mexico, highly responsive to fertilizer and essentially insensitive to photoperiod, maturing in 130 days. Under irrigation it yielded 9 tons/ha in the dry season and, on the IRRI farm, when continuously cultivated with a rapid turnaround between crops, produced average annual yields of over 20 tons/ha. In Asian regional trials it outyielded virtually all other varieties, producing from 5–10 tons/ha.

There was an immediate impact on Philippine rice production. By 1970, one and a half million hectares, or half of the Philippines' riceland, was planted to the new varieties and the yield take-off had occurred. The Philippines became self-sufficient in rice production in 1968 and 1969 for the first time in decades, although this was temporarily lost in the early 1970s owing to bad weather and disease outbreaks. A decade later, 75 per cent of the riceland was planted to the new varieties, average yields were over 2000kg/ha and rising at nearly 70kg/ha per year (Figure 13.4).

To begin with, the new varieties were distributed somewhat haphazardly. When IR8 was first released, farmers who turned up at IRRI could have 2kg of seed free, provided they left their name and address. The seed spread within a few months to over two-thirds of the provinces of the Philippines. Later, seed was distributed through government agencies and a newly formed Seed Growers Association, composed of private farmers who both grew and marketed the new seed. Standard Oil of New Jersey (ESSO) also established 400 agroservice centres in the Philippines to serve as marketing outlets not only for fertilizer but for seed, pesticides and farm implements.[17]

Two Mexican farm advisers working in El Salvador had hit on the idea of putting together in one package all the basic inputs a farmer would need to try out a new variety on a small patch of ground. The idea quickly spread to other countries and was tried on a massive scale in the Philippines, where a typical package contained 0·9kg of IR8 seed, 19kg of fertilizer and 2·7kg of insecticide. The packages were

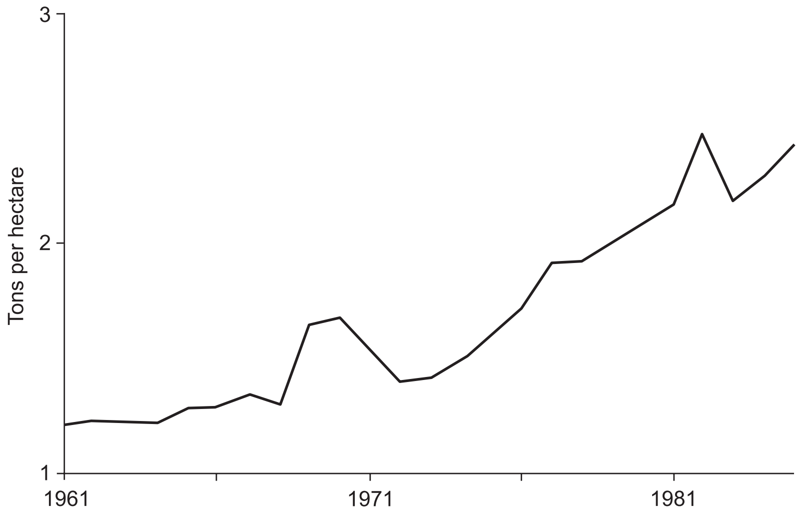


Figure 13.4 *Rice yields in the Philippines, 1961–1985*

produced by governments and also sold by fertilizer companies.[18] In addition to continuing its programme of food aid, the US aid agency, USAID, began to support fertilizer shipments in the 1960s and to finance rural infrastructure – farm-to-market roads, irrigation projects and rural electrification. It also funded a large force of technical assistance experts. Contracts were signed with US land-grant colleges to assist institution-building in education, research and extension and to create agricultural universities in the land-grant tradition. One of the most successful partnerships was between Cornell University and the University of the Philippines at Los Banos, next to the IRRI campus.

A conscious objective of the Green Revolution, from the beginning, was to produce varieties that could be grown in a wide range of conditions throughout the developing world. To meet this goal, the breeders in Mexico had successfully bred the new wheats to be photoperiod-insensitive, that is, they would flower and produce grain at any time of year, in contrast to traditional varieties which tend to flower at certain seasons, for example when the days are shortening. Provided the temperature was above a certain minimum and there was sufficient water, the new varieties would grow almost anywhere.

As early as the 1950s, successful trials of the new Mexican maize and wheat varieties were conducted in Latin America and Asia. The new varieties in India yielded at least a ton more than the local varieties. However, local pests and diseases and location-specific soil-management problems remained major constraints. And the importance of getting the package right was illustrated by an attempt to introduce the Mexican soft wheats to Tunisia, where the farmers are used to growing hard wheats, eaten in the form of couscous.[19] In the first year the trials gave average yields of 1·5 tons/ha, three times that of the hard wheat. The early maturity of the soft wheats also meant they could be harvested quickly before the drought set in. But the greatly expanded planting in the third year was a catastrophe, with yields of only 300kg/ha. The seed was of poor quality and, because of a complicated bureaucracy, was distributed too late. The farmers also planted it too deep for fear of drought and failed to keep the weeds down. In the fourth year they reverted to the traditional hard-wheat varieties.

To oversee the international effort, a wheat and maize improvement programme was established in 1966 under the umbrella of the International Centre for the Improvement of Maize and Wheat, located at Chapingo in Mexico and known by the initials (from its Spanish name) CIMMYT. The new seeds were mostly exported at a price very little above the world market price. In 1967–1968 Pakistan imported sufficient of the new wheat seeds to plant more than 400,000 hectares. Pakistan and India's yield take-offs occurred in 1967; subsequent yield increases were about 50kg/ha per year (Figure 13.5). A major impetus for the rapid uptake of the new varieties in South Asia was the two consecutive failures of the monsoon in 1966 and 1967. The US, which was the only country carrying food reserves of any size, had responded by shipping one-fifth of its grain crop to India.[20] This degree of dependence was recognized by both sides as being risky and undesirable. In some instances, food-aid agreements had permitted countries to put off serious agricultural development plans, and the large volume of food received had depressed prices and reduced the incentive for farmers to produce more. Then the monsoon failures helped to wipe out the world's surpluses and prices rose dramatically (rice going from \$120 to over \$200/ton in 1967). Faced with a food crisis of this magnitude, a number of developing-country leaders quickly recognized the potential of the new varieties. Presidents Ayub of Pakistan and Marcos of the Philippines and Prime Minister Demirel of Turkey took a personal and active part in the promotion of the Green Revolution, and were able to

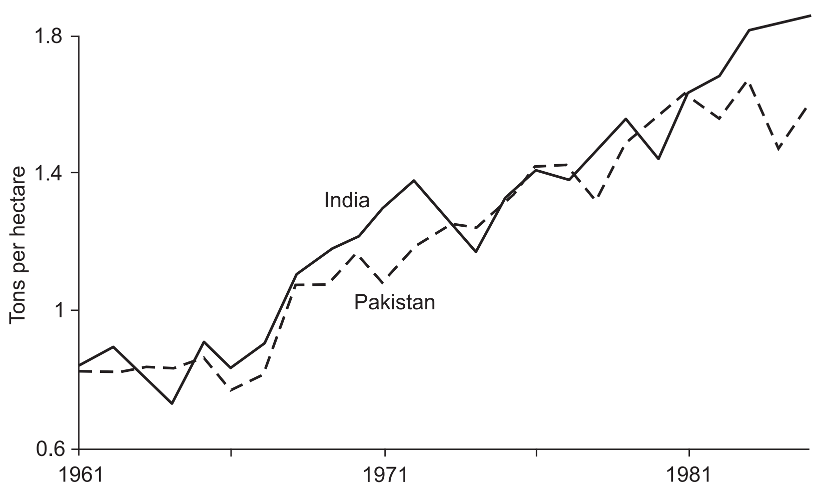


Figure 13.5 *Growth in wheat yields in India and Pakistan*

take some of the credit for its success. The re-election of President Marcos in 1969 owed much to the attainment of self-sufficiency in rice production.

The new wheats also proved popular in Argentina, where their early maturity made them appropriate for double-cropping with soybeans.[21] And in Egypt wheat yields took off in 1969, initially growing at over 60kg/ha per year but after 1980 at 200kg/ha.[22] The hybrid maizes were also successfully introduced into Egypt and into Kenya and Zimbabwe. However, the biggest impact came from their adoption in Latin America. To begin with this was slow because the traditional peasant farmers were reluctant to switch from the open-pollinated varieties which could be retained as seed on the farm for next year's harvest. However, by the early 1980s half the maize area of Latin America was sown to hybrids and yields had grown by a third since 1960. Chile, in particular, experienced dramatic growth, at over 200kg/ha per year after take-off in 1964. According to Donald Plucknett of the CGIAR this is the highest sustained growth rate that any cereal has so far experienced.[23] Average yields in 1985 were approaching 6 tons/ha.

The uptake of the new rice varieties was similarly dramatic. Twenty tons of IR8 seed were sent to India in 1966 and a further 5 tons to other Asian and Latin American countries. In Colombia it gave rise to a number of local variants developed by the Centre for Tropical Agriculture (Centro Internacional de Agricultura Tropical – CIAT) which soon replaced the indigenous varieties. By 1985 average yields were approaching 5 tons/ha and rice had become the dominant Colombian food crop.[24] Another remarkable transformation occurred in Indonesia, where oil revenues were used to finance the adoption of the new varieties and their accompanying packages. The take-off occurred in 1967, with subsequent rice-yield increases of over 100kg/ha (Figure 13.6).

Figure 13.6 *The growth of rice yields in Indonesia*

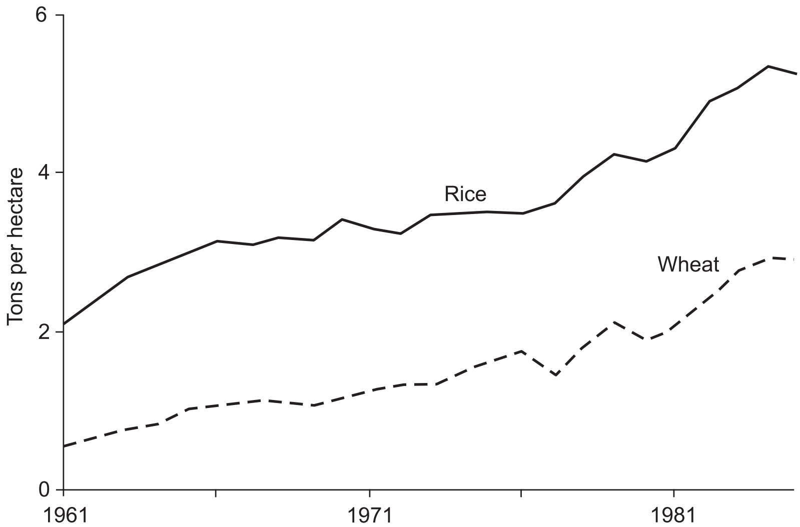


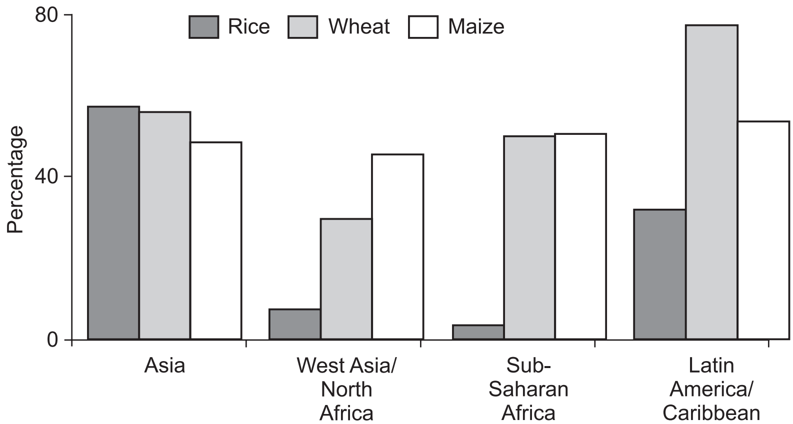
Figure 13.7 *Growth of rice and wheat yields in China*

In China rice yields gained an extra boost from the development of hybrid rice. Rice, like wheat, is self-pollinating but the Chinese developed an inexpensive technique permitting cross-pollination on a large scale. The resulting hybrid rices have the same qualities of hybrid vigour as the hybrid maizes: yields are some 20 per cent, or about a ton, greater than the semi-dwarf rices. The first hybrid rice was distributed in 1974 and within a few years it was being planted on 15 per cent of Chinese riceland. China also introduced new high-yielding wheats from Mexico and crossed them with local varieties. Grain yields grew steadily in the 1970s and then accelerated after 1978, following the break-up of the communes, the re-establishment of the household as the unit of production and the encouragement of local markets (Figure 13.7).[25]

By the 1980s the Green Revolution and new Chinese varieties were dominating the grain lands of the developing world (Figure 13.8).[26]

Inevitably, there were many ‘teething problems’ in the early years. Governments were unprepared for the rapid rise in production. The land planted to IR8 in Pakistan increased a hundredfold, to over 400,000 hectares, in only a year. Storage, transport and marketing systems were sometimes overwhelmed. The 1968 Indian wheat harvest was one-third greater than the previous record and schools had to be closed in order to store the grain.[27] A huge harvest in Kalimantan, on the island of Borneo, went to waste because there was insufficient transport to get it to the centres of demand in Java. But these were the problems of success and they were quickly overcome.

Another early problem was the poor acceptability of some of the new varieties. Even poor, undernourished people retain a pride in eating good-quality grain. There was preference in India and Pakistan for chapatis made from the traditional



Source: M. Lipton and R. Longhurst, 1989, *New Seeds and Poor People*, London, Unwin Hyman

Figure 13.8 *Proportion of cereal lands under new Green Revolution or Chinese varieties in the early 1980s*

white grains rather than the reddish grains of the new varieties, but this problem was soon solved by breeding for white grain colour.[28] The grain of the first IRRI rices, such as IR8, was also rejected because it tended to harden excessively after cooking and farmers received a lower price than for the traditional grains. Quality improved with later varieties, but many farmers continued to prefer the traditional taste. In Indonesia the growing of traditional rice varieties was prohibited, a ban sometimes enforced by the destruction of crops in the fields. Farmers responded by cultivating the traditional rices in their home gardens or on the margins of fields growing the new varieties.

Other problems were more persistent and less amenable to simple solutions. They often required changes in government policies and the creation of new agencies. Inevitably the solutions created yet further problems. An example was the credit needs of the new technology. Adoption of the high-yielding packages was expensive: in Bangladesh the cost of the necessary inputs was 60 per cent more than for the traditional varieties. Small, subsistence farmers, often tenants or sharecroppers, could only afford the new packages if they borrowed from local moneylenders, invariably at high rates of interest. In the Philippines, where the majority of farmers are tenants, cash was borrowed from the landlords at rates of 60–90 per cent per annum, often producing a permanent state of indebtedness. The government response was to set up an Agricultural Guarantee Loan Fund, established at the Central Bank. This, in turn, supported numerous private rural banks which loaned without collateral and at reasonable interest rates. It was an important factor in determining the very rapid uptake of the new varieties in the Philippines.

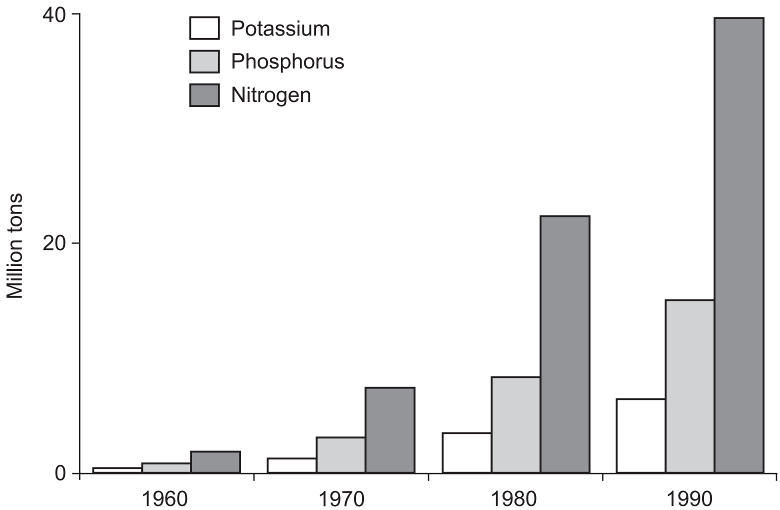
However, there were drawbacks. Under the traditional feudal system, the tenants provided personal services for the landlord, gathering fuel or lending a hand with house repairs. In return, landlords helped with rice or money at times of economic hardship, providing a degree of protection against the outside world.[29] With the advent of the Green Revolution, this relationship became more commercial. Both sides benefited: yields on tenant farms rapidly increased as farmers gained from the landlord's better access to technical information, machinery and inputs. But the inputs had to be paid for and in bad years there was no longer any latitude. Credit repayments under the government scheme were due on schedule and defaulters were punished. The banks were less accommodating than the landlords.

Governments usually intervened directly to assure the supply of inputs. Demand for fertilizers grew rapidly in the early years, sometimes outstripping supply and forcing up prices.[30] The response was to fix prices and provide generous subsidies. Under the BIMAS programme in Indonesia, quotas were awarded to licensed importers, prices were fixed and distributors and retailers appointed right down to the cooperatives at village level. By the mid-1980s the subsidy for fertilizers had reached 68 per cent of the world price, for pesticides 40 per cent and for water nearly 90 per cent. Such high levels of subsidy created serious environmental problems. Also because the distribution of subsidized inputs tended to remain in the hands of government or quasi-government agencies, corruption became widespread and, in some situations, institutionalized. This has been most evident in government irrigation schemes.[31]

Pest and disease outbreaks have been an especially severe consequence of the Green Revolution.[32] In some cases the cause-and-effect relationship is simple. Pest populations have grown in response to higher nitrogen applications and diseases have become more prevalent in the microclimate created by the densely leaved, short-strawed wheats and rices. But often it is a combination of factors – higher nutrient levels, narrow genetic stock, uniform continuous planting and the misuse of pesticides – that have created conditions which encourage pest and disease attack.

According to some critics of the Green Revolution, the growth in production owed little to the new varieties, and was primarily due to agricultural expansion, arable cultivation moving on to increasingly marginal lands. But the evidence is otherwise: although area increases were important in the 1950s, the subsequent gains were largely derived from increasing yield per hectare. Other commentators claim the growth in production has been due to infrastructural and institutional change rather than the specific technical innovations, pointing to the lack of signs of the impact of the new varieties in the regional data.[33] But this is because the individual country take-offs, so clearly indicated in the graphs in this chapter, were staggered and hence are masked when aggregated together.

Nevertheless, the yield growth was not solely attributable to the new varieties. They were necessary but not sufficient alone for success. Their potential could only be realized if they were supplied with high quantities of fertilizer and provided with optimal supplies of water. As was soon apparent, the new varieties yielded better than the traditional at any level of fertilizer application, although



Source: FAO, 1994 [Fertilizer data diskettes], Rome, Food and Agriculture Organization

Figure 13.9 *The growth of fertilizer use in the developing countries*

without fertilizer they sometimes did worse on poor soils.[34] Not surprisingly, average rates of application of nitrogen fertilizers, mostly ammonium sulphate and urea, doubled and redoubled over a very short period (Figure 13.9).

Because the new varieties were more exacting in their requirements, good irrigation, by providing a controlled environment for growth, became crucial. Most developing countries have both a dry and a wet growing season. Potentially, dry-season yields are 50–100 per cent greater than in the wet, but the lack of rainfall in the dry season and the high evapotranspiration rates resulting from absence of cloud cover make the crops liable to water stress. Without adequate irrigation, yields tend to be low and variable, whatever the level of fertilizer application. With irrigation and heavy fertilizer application, some of the highest cereal yields in the world have been attained. In south and southeast Asia the irrigated area grew from some 40 million hectares to over 65 million hectares between 1960 and 1980, a growth rate of 2·2 per cent per annum. By 1980 one-third of the rice area was irrigated, producing a rapid increase in the dry-season rice crop.

Just how much of the increased cereal production has been due to the availability of the new varieties, how much to increased fertilizer use and how much to the growth of irrigation is a matter of argument. An analysis of the eight countries (Bangladesh, Burma, China, India, Indonesia, Philippines, Sri Lanka and Thailand) responsible for 85 per cent of the Asian rice crop suggested the three factors had a roughly equal contribution. Of the extra 117 million tons produced between 1965 and 1980, 27 million tons were attributable to the new varieties, 29 million tons to increased fertilizer use and 34 million tons to irrigation.[35]

Inevitably, the need to provide high levels of fertilizer and controlled, irrigated environments meant that some locations were favoured over others.

Uptake was fastest and most dramatic in those lands such as Sonora in Mexico, Luzon in the Philippines, the lowlands of Java, and the Punjab of India and Pakistan where irrigation was already well developed and where farmers, often larger than in the rest of the country, had good access to credit, had a greater propensity to take risks and were likely to be rapid adopters. Most important, innovation and adoption there was supported by governments willing and able to make and direct the necessary investments, including the necessary research structure which could take and adapt the new varieties to local conditions. These lands, scattered through Asia and Latin America, became the so-called Green Revolution lands.

In summary, the Green Revolution succeeded because it focused on three interrelated actions:

- breeding programmes for staple cereals to produce early-maturing, day-length-insensitive and high-yielding varieties;
- the organization and distribution of packages of high-pay-off inputs, such as fertilizers, pesticides and water regulation;
- implementation of these technical innovations in the most favourable agroclimatic regions and for those classes of farmers with the best expectations of realizing the potential yields.

In many ways this was a triumph for technology, rather than science. The dwarfing genes had been known for decades in China and Japan and most of the breeding techniques were well established. What made the difference was the investment, in China and independently in the rest of the developing world, in institutions and in the organization of delivery of the inputs necessary to make the science productive.

The success is undisputed, but it has been a revolution with serious limitations. In particular:

- its impact on the poor has been less than expected;
- it has not reduced, and in some cases it has encouraged, natural-resource degradation and environmental problems;
- its geographic impact has been localized; and
- there are signs of diminishing returns.

Notes

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2 The basis for determining who is 'hungry' has changed over time, and the figure would probably be lower if the current method of determining 'chronic undernourishment' was used. See D Grigg, 1993. *The World Food Problem* (2nd edn), Oxford, Blackwell

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23 ibid.

24 Grigg, op. cit.

25 ibid.

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14

Soviet Collectivization, Capitalist Dreams

J. C. Scott

The master builders of Soviet society were rather more like Niemeyer designing Brasília than Baron Haussmann retrofitting Paris. A combination of defeat in war, economic collapse and a revolution had provided the closest thing to a bulldozed site that a state builder ever gets. The result was a kind of ultrahigh modernism that in its audacity recalled the Utopian aspects of its precursor, the French Revolution.

This is not the place, nor am I the most knowledgeable guide, for an extensive discussion of Soviet high modernism.[1] What I aim to do, instead, is to emphasize the cultural and aesthetic elements in Soviet high modernism. This will in turn pave the way for an examination of an illuminating point of direct contact between Soviet and American high modernism: the belief in huge, mechanized, industrial farms.

In certain vital respects, Soviet high modernism is not a sharp break from Russian absolutism. Ernest Gellner has argued that of the two facets of the Enlightenment – the one asserting the sovereignty of the individual and his interests, the other commending the rational authority of experts – it was the second that spoke to rulers who wanted their 'backward' states to catch up. The Enlightenment arrived in Central Europe, he concludes, as a 'centralizing rather than a liberating force'.[2]

Strong historical echoes of Leninist high modernism can thus be found in what Richard Stites calls the 'administrative utopianism' of the Russian czars and their advisers in the 18th and 19th centuries. This administrative utopianism found expression in a succession of schemes to organize the population (serfs, soldiers, workers, functionaries) into institutions 'based upon hierarchy, discipline, regimentation, strict order, rational planning, a geometrical environment, and a form of welfarism'.[3] Peter the Great's Saint Petersburg was the urban realization of this vision. The city was laid out according to a strict rectilinear and radial plan on completely new terrain. Its straight boulevards were, by design, twice as wide as the tallest building, which was, naturally, at the geometric centre of the city. The buildings themselves reflected function and hierarchy, as the façade, height and material of each corresponded to the social class of its inhabitants. The city's physical layout was in fact a legible map of its intended social structure.

Reprinted from Scott J C. 1998. Soviet collectivism, capitalist dreams, in *Seeing Like a State.* Yale University Press, New Haven, pp193–222.

Saint Petersburg had many counterparts, urban and rural. Under Catherine the Great, Prince Grigory Potemkin established a whole series of model cities (such as Ekaterinoslav) and model rural settlements. The next two czars, Paul and Alexander I, inherited Catherine's passion for Prussian order and efficiency.[4] Their adviser, Alexei Arakcheev, established a model estate on which peasants wore uniforms and followed elaborate instructions on upkeep and maintenance, to the point of carrying 'punishment books' inscribed with records of their violations. This estate was made the basis of a far bolder plan for a network of widely scattered, self-sufficient military colonies, which by the late 1820s included 750,000 people. This attempt to create a new Russia, in contrast to the disorder, mobility and flux of a frontier society, quickly succumbed to popular resistance, corruption and inefficiency. Long before the Bolsheviks took power, in any case, the historical landscape was littered with the wreckage of many miscarried experiments in authoritarian social planning.

Lenin and his confederates could implement their high-modernist plans starting from nearly zero. The war, the revolution and the subsequent famine had gone a long way toward dissolving the prerevolutionary society, particularly in the cities. A general collapse of industrial production had provoked a vast exodus from the cities and a virtual regression to a barter economy. The ensuing four-year civil war further dissolved existing social ties as well as schooling the hard-pressed Bolsheviks in the methods of 'war Communism' – requisitions, martial law, coercion.

Working on a levelled social terrain and harbouring high-modernist ambitions in keeping with the distinction of being the pioneers of the first socialist revolution, the Bolsheviks thought big. Nearly everything they planned was on a monumental scale, from cities and individual buildings (the Palace of Soviets) to construction projects (the White Sea Canal) and, later, the great industrial projects of the first Five-Year Plan (Magnitogorsk), not to mention collectivization. Sheila Fitzpatrick has appropriately called this passion for sheer size 'gigantomania'.[5] The economy itself was conceived as a well-ordered machine, where everyone would simply produce goods of the description and quantity specified by the central state's statistical bureau, as Lenin had foreseen.

A transformation of the physical world was not, however, the only item on the Bolshevik agenda. It was a cultural revolution that they sought, the creation of a new person. Members of the secular intelligentsia were the most devoted partisans of this aspect of the revolution. Campaigns to promote atheism and to suppress Christian rituals were pressed in the villages. New 'revolutionary' funeral and marriage ceremonies were invented amidst much fanfare, and a ritual of 'Octobering' was encouraged as an alternative to baptism.[6] Cremation – rational, clean, economical – was promoted. Along with this secularization came enormous and widely popular campaigns to promote education and literacy. Architects and social planners invented new communal living arrangements designed to supersede the bourgeois family pattern. Communal food, laundry and child-care services promised to free women from the traditional division of labour. Housing arrangements were explicitly intended to be 'social condensers'.

The 'new man' – the Bolshevik specialist, engineer or functionary – came to represent a new code of social ethics, which was sometimes simply called *kultura*. In keeping with the cult of technology and science, kultura emphasized punctuality, cleanliness, businesslike directness, polite modesty, and good, but never showy, manners.[7] It was this understanding of kultura and the party's passion for the League of Time, with its promotion of time consciousness, efficient work habits and clock-driven routine, that were so brilliantly caricatured in Eugene Zamiatin's novel *We* and that later became the inspiration for George Orwell's *1984*.

What strikes an outside observer of this revolution in culture and architecture is its emphasis on public form – on getting the visual and aesthetic dimensions of the new world straight. One can perhaps see this best in what Stites calls the 'festivals of mustering' organized by the cultural impresario of the early Soviet state, Anatoly Lunacharsky.[8] In the outdoor dramas he produced, the revolution was reenacted on a scale that must have seemed as large as the original, with cannons, bands, searchlights, ships on the river, 4000 actors and 35,000 spectators.[9] Whereas the actual revolution had all the usual messiness of reality, the reenactment called for military precision, and the various actors were organized by platoon and mobilized with semaphore and field telephones. Like mass exercises, the public spectacle gave a retroactive order, purpose and central direction to the events, which were designed to impress the spectator, not to reflect the historical facts.[10] If one can see in Arakcheev's military colonies an attempt to prefigure, to represent, a wished-for order, then perhaps Lunacharsky's staged revolution can be seen as a representation of the wished-for relationship between the Bolsheviks and the proletarian crowd. Little effort was spared to see that the ceremony turned out right. When Lunacharsky himself complained that churches were being demolished for the May Day celebrations, Lazar Kaganivich, the city boss of Moscow, replied, 'And *my* aesthetics demand that the demonstration processions from the six districts of Moscow should all pour into Red Square at the same time.'[11] In architecture, public manners, urban design and public ritual, the emphasis on a visible, rational, disciplined social facade seemed to prevail.[12] Stites suggests that there is some inverse relation between this public face of order and purpose and the near anarchy that reigned in society at large: 'As in the case of all such Utopias, its organizers described it in rational, symmetrical terms, in the mathematical language of planning, control figures, statistics, projections and precise commands. As in the vision of military colonies, which the Utopian plan faintly resembled, its rational facade barely obscured the oceans of misery, disorder, chaos, corruption and whimsicality that went with it.'[13]

One possible implication of Stites's assertion is that, in some circumstances, what I call the miniaturization of order may be substituted for the real thing. A facade or a small, easily managed zone of order and conformity may come to be an end in itself; the representation may usurp the reality. Miniatures and small experiments have, of course, an important role in studying larger phenomena. Model aircraft built to scale and wind tunnels are essential steps in the design of new airplanes. But when the two are confused – when, say, the general mistakes the parade ground for the battlefield itself – the consequences are potentially disastrous.

A Soviet-American Fetish: Industrial Farming

Before plunging into a discussion of the practice and logic of Soviet collectivization, we should recognize that the rationalization of farming on a huge, even national, scale was part of a faith shared by social engineers and agricultural planners throughout the world.[14] And they were conscious of being engaged in a common endeavour. Like the architects of the Congrès Internationaux d'Architecture Moderne, they kept in touch through journals, professional conferences and exhibitions. The connections were strongest between US agronomists and their Russian colleagues – connections that were not entirely broken even during the Cold War. Working in vastly different economic and political environments, the Russians tended to be envious of the level of capitalization, particularly in mechanization, of US farms while the Americans were envious of the political scope of Soviet planning. The degree to which they were working together to create a new world of large-scale, rational, industrial agriculture can be judged by this brief account of their relationship.

The high tide of enthusiasm for applying industrial methods to agriculture in the US stretched roughly from 1910 to the end of the 1930s. Agricultural engineers, a new specialty, were the main carriers of this enthusiasm; influenced by currents in their parent discipline, industrial engineering, and most particularly by the doctrines of the prophet of time–motion studies, Frederick Taylor, they reconceptualized the farm as a 'food and fiber factory'.[15] Taylorist principles of scientifically measuring work processes in order to break them down into simple, repetitive motions that an unskilled worker could learn quickly might work well enough on the factory floor,[16] but their application to the variegated and nonrepetitive requirements of growing crops was questionable. Agricultural engineers therefore turned to those aspects of farm operation that might be more easily standardized. They tried to rationalize the layout of farm buildings, to standardize machinery and tools, and to promote the mechanization of major grain crops.

The professional instincts of the agricultural engineers led them to try to replicate as much as possible the features of the modern factory. This impelled them to insist on enlarging the scale of the typical small farm so that it could mass-produce standard agricultural commodities, mechanize its operation, and thereby, it was thought, greatly reduce the unit cost of production.[17]

As we shall see later, the industrial model was applicable to some, but not all, of agriculture. It was nonetheless applied indiscriminately as a creed rather than a scientific hypothesis to be examined sceptically. The modernist confidence in huge scale, centralization of production, standardized mass commodities and mechanization was so hegemonic in the leading sector of industry that it became an article of faith that the same principles would work, *pari passu*, in agriculture.

Many efforts were made to put this faith to the test. Perhaps the most audacious was the Thomas Campbell 'farm' in Montana, begun – or, perhaps I should say, founded – in 1918.[18] It was an industrial farm in more than one respect. Shares were sold by prospectuses describing the enterprise as an 'industrial opportunity';

J. P. Morgan, the financier, helped to raise $2 million from the public. The Montana Farming Corporation was a monster wheat farm of 95,000 acres, much of it leased from four Native American tribes. Despite the private investment, the enterprise would never have gotten off the ground without help and subsidies from the Department of Interior and the USDA.

Proclaiming that farming was about 90 per cent engineering and only 10 per cent agriculture, Campbell set about standardizing as much of his operation as possible. He grew wheat and flax, two hardy crops that needed little if any attention between planting and harvest time.[19] The land he farmed was the agricultural equivalent of the bulldozed site of Brasília. It was virgin soil, with a natural fertility that would eliminate the need for fertilizer. The topography also vastly simplified matters: it was flat, with no forests, creeks, rocks or ridges that would impede the smooth course of machinery over its surface. In other words, the selection of the simplest, most standardized crops and the leasing of something very close to a blank agricultural space were calculated to favour the application of industrial methods. In the first year Campbell bought 33 tractors, 40 binders, 10 threshing machines, 4 combines and 100 wagons; he employed about 50 men most of the year, but hired as many as 200 during the peak season.[20]

This is not the place to chronicle the fortunes of the Montana Farming Corporation, and in any event Deborah Fitzgerald has done so splendidly.[21] Suffice it to note that a drought in the second year and the elimination of government support for prices the following year led to a collapse that cost J. P. Morgan $1 million. The Campbell farm faced other problems besides weather and prices: soil differences, labour turnover, the difficulty of finding skilled, resourceful workers who would need little supervision. Although the corporation struggled on until Campbell's death in 1966, it provided no evidence that industrial farms were superior to family farms in efficiency and profitability. The advantages industrial farms did have over smaller producers were of another kind. Their very size gave them an edge in access to credit, political influence (relevant to taxes, support payments and the avoidance of foreclosure) and marketing muscle. What they gave away in agility and quality labour they often made up for in their considerable political and economic clout.

Many large industrial farms managed along scientific lines were established in the 1920s and 1930s.[22] Some of them were the stepchildren of depression foreclosures that left banks and insurance companies holding many farms they could not sell. Such 'chain farms', consisting of as many as 600 farmsteads organized into one integrated operation (one farm to farrow pigs, say, and another to feed them out, along the lines of contemporary 'contract farming' for poultry), were quite common, and buying into them was a speculative investment.[23] They proved no more competitive to the family farm than did Campbell's corporation. In fact, they were so highly capitalized that they were vulnerable to unfavourable credit markets and lower farm gate prices, given their high fixed costs in payroll and interest. The family farm could, by contrast, more easily tighten its belt and move into a subsistence mode.

The most striking proposal designed to reconcile the American small-property regime with huge economies of scale and scientific, centralized management was that of Mordecai Ezekial and Sherman Johnson in 1930. They outlined a 'national farming corporation' that would incorporate all farms. It would be vertically integrated and centralized and 'could move raw farming materials through the individual farms of the country, could establish production goals and quotas, distribute machinery, labor and capital, and move farm products from one region to another for processing and use. Bearing a striking resemblance to the industrial world, this organizational plan was a sort of gigantic conveyor belt'.[24] Ezekial was no doubt influenced by his recent tour of Russian collective farms as well as by the plight of the depression-stricken economy. Johnson and Ezekial were hardly alone in calling for centralized industrial farming on a massive scale, not just as a response to economic crisis but as a matter of confidence in an ineluctable high-modernist future. The following expression of that confidence is fairly representative: 'Collectivization is posed by history and economics. Politically, the small farmer or peasant is a drag on progress. Technically, he is as antiquated as the small machinists who once put automobiles together by hand in little wooden sheds. The Russians have been the first to see this clearly, and to adapt themselves to historical necessity.'[25]

Behind these admiring references to Russia was less a specifically political ideology than a shared high-modernist faith. That faith was reinforced by something on the order of an improvised, high-modernist exchange programme. A great many Russian agronomists and engineers came to the US, which they regarded as the Mecca of industrial farming. Their tour of US agriculture nearly always included a visit to Campbell's Montana Farming Corporation and to M. L. Wilson, who in 1928 headed the Department of Agricultural Economics at Montana State University and later became a high-level official in the Department of Agriculture under Henry Wallace. The Russians were so taken with Campbell's farm that they said they would provide him with 1 million acres if he would come to the Soviet Union and demonstrate his farming methods.[26]

Traffic in the other direction was just as brisk. The Soviet Union had hired thousands of US technicians and engineers to help in the design of various elements of Soviet industrial production, including the production of tractors and other farm machinery. By 1927, the Soviet Union had also purchased 27,000 American tractors. Many of the American visitors, such as Ezekial, admired Soviet state farms, which by 1930 offered the promise of collectivized agriculture on a massive scale. The Americans were impressed not just by the sheer size of the state farms but also by the fact that technical specialists – agronomists, economists, engineers, statisticians – were, it seemed, developing Russian production along rational, egalitarian lines. The failure of the Western market economy in 1930 reinforced the attractiveness of the Soviet experiment. Visitors travelling in either direction returned to their own country thinking that they had seen the future.[27]

As Deborah Fitzgerald and Lewis Feuer argue, the attraction that collectivization held for American agricultural modernizers had little to do with a belief in

Marxism or an affinity for Soviet life.[28] 'Rather it was because the Soviet idea of growing wheat on an industrial scale and in an industrial fashion was similar to US ideas about the direction American agriculture should take.'[29] Soviet collectivization represented, to these American viewers, an enormous demonstration project without the political inconveniences of American institutions; 'that is, the Americans viewed the giant Soviet farms as huge experiment stations on which Americans could try out their most radical ideas for increasing agricultural production, and, in particular, wheat production. Many of the things they wished to learn more about simply could not be tried in America, partly because it would cost too much, partly because no suitable large farmsite was available, and partly because many farmers and farm laborers would be alarmed at the implications of this experimentation.'[30] The hope was that the Soviet experiment would be to American industrial agronomy more or less what the Tennessee Valley Authority was to be to American regional planning: a proving ground and a possible model for adoption.

Although Campbell did not accept the Soviet offer of a vast demonstration farm, others did. M. L. Wilson, Harold Ware (who had extensive experience in the Soviet Union), and Guy Riggin were invited to plan a huge mechanized wheat farm of some 500,000 acres of virgin land. It would be, Wilson wrote to a friend, the largest mechanized wheat farm in the world. They planned the entire farm layout, labour force, machinery needs, crop rotations and lockstep work schedule in a Chicago hotel room in two weeks in December 1928.[31] The fact that they imagined that such a farm *could* be planned in a Chicago hotel room underlines their presumption that the key issues were abstract, technical interrelationships that were context-free. As Fitzgerald perceptively explains: 'Even in the U.S., those plans would have been optimistic, actually, because they were based on an unrealistic idealization of nature and human behavior. And insofar as the plans represented what the Americans would do if they had millions of acres of flat land, lots of laborers, and a government commitment to spare no expense in meeting production goals, *the plans were designed for an abstract, theoretical kind of place*. This agricultural place, which did not correspond to America, Russia, or any other actual location, obeyed the laws of physics and chemistry, recognized no political or ideological stance.'[32]

The giant *sovkhoz*, named Verblud, which they established near Rostov-on-Don, one thousand miles south of Moscow, comprised 375,000 acres that were to be sown to wheat. As an economic proposition, it was an abject failure, although in the early years it did produce large quantities of wheat. The detailed reasons for the failure are of less interest for our purposes than the fact that most of them could be summarized under the rubric of *context*. It was the specific context of this specific farm that defeated them. The farm, unlike the plan, was not a hypothecated, generic, abstract farm but an unpredictable, complex and particular farm, with its own unique combination of soils, social structure, administrative culture, weather, political strictures, machinery, roads and the work skills and habits of its employees. As we shall see, it resembled Brasília in being the kind of failure typical of ambitious high-modernist schemes for which local knowledge practice, and context are considered irrelevant or at best an annoyance to be circumvented.

Collectivization in Soviet Russia

> *What we have here isn't a mechanism, it's people living here. You can't get them squared around until they get themselves arranged. I used to think of the revolution as a steam engine, but now I see that it's not.*
>
> Andrei Platonov, *Chevengur*

The collectivization of Soviet agriculture was an extreme but diagnostic case of authoritarian high-modernist planning. It represented an unprecedented transformation of agrarian life and production, and it was imposed by all the brute force at the state's disposal. The officials who directed this massive change, moreover, were operating in relative ignorance of the ecological, social and economic arrangements that underwrote the rural economy. They were flying blind.

Between early 1930 and 1934, the Soviet state waged a virtual war in the countryside. Realizing that he could not depend on the rural Soviets to 'liquidate the *kulaks*' and collectivize, Stalin dispatched 25,000 battle-tested, urban Communists and proletarians with full powers to requisition grain, arrest resistors and collectivize. He was convinced that the peasantry was trying to bring down the Soviet state. In reply to a personal letter from Mikhail Sholokhov (author of *And Quiet Flows the Don*) alerting him to the fact that peasants along the Don were on the verge of starvation, Stalin replied, 'The esteemed grain growers of your district (and not only of your district alone) carried on an "Italian strike" (*ital'ianka*), sabotage!, and were not loathe to leave the workers and the Red Army without bread. That the sabotage was quiet and outwardly harmless (without bloodshed) does not change the fact that the esteemed grain growers waged what was virtually a "quiet" war against Soviet power. A war of starvation, dear comrade Sholokhov.'[33]

The human costs of that war are still in dispute, but they were undeniably grievous. Estimates of the death toll alone, as a result of the 'dekulakization' and collectivization campaigns and the ensuing famine, range from a 'modest' 3 or 4 million to, as some current Soviet figures indicate, more than 20 million. The higher estimates have, if anything, gained more credibility as new archival material has become available. Behind the deaths rose a level of social disruption and violence that often exceeded that of the civil war immediately following the revolution. Millions fled to the cities or to the frontier, the infamous gulag was vastly enlarged, open rebellion and famine raged in much of the countryside, and more than half of the nation's livestock (and draft power) was slaughtered.[34]

By 1934, the state had 'won' its war with the peasantry. If ever a war earned the designation 'Pyrrhic victory', this is the one. The *sovkhoz* (state farms) and *kolkhoz* (collective farms) failed to deliver on any of the specifically socialist goals envisioned by Lenin, Trotsky, Stalin and most Bolsheviks. They were an evident failure in raising the level of grain production or of producing cheap and abundant foodstuffs for an urban, industrializing workforce. They failed to become the technically efficient and innovative farms that Lenin had anticipated. Even in the realm of electrification, Lenin's touchstone of modernization, only 1 in 25 collective farms had electricity by the eve of World War II. By no measure had the collectivization of agriculture created 'new men and women' in the countryside or abolished the cultural difference between the country and the city. For the next half-century, the yields per hectare of many crops were stagnant or actually inferior to the levels recorded in the 1920s or the levels reached before the Revolution.[35]

At another level, collectivization was, in a curious state-centric way, a qualified success. Collectivization proved a rough-and-ready instrument for the twin goals of traditional statecraft: appropriation and political control. Though the Soviet kolkhoz may have failed badly at generating huge surpluses of foodstuffs, it served well enough as a means whereby the state could determine cropping patterns, fix real rural wages, appropriate a large share of whatever grain was produced, and politically emasculate the countryside.[36]

The great achievement, if one can call it that, of the Soviet state in the agricultural sector was to take a social and economic terrain singularly unfavourable to appropriation and control and to create institutional forms and production units far better adapted to monitoring, managing, appropriating and controlling from above. The rural society that the Soviet state inherited (and for a time encouraged) was one in which the allies of the czarist state, the great landlords and the aristocratic officeholders, had been swept away and been replaced by smallholding and middle peasants, artisans, private traders and all sorts of mobile labourers and lumpen elements.[37] Confronting a tumultuous, footloose and 'headless' (acephalous) rural society which was hard to control and which had few political assets, the Bolsheviks, like the scientific foresters, set about redesigning their environment with a few simple goals in mind. They created, in place of what they had inherited, a new landscape of large, hierarchical, state-managed farms whose cropping patterns and procurement quotas were centrally mandated and whose population was, by law, immobile. The system thus devised served for nearly 60 years as a mechanism for procurement and control at a massive cost in stagnation, waste, demoralization and ecological failure.

That collectivized agriculture persisted for 60 years was a tribute less to the plan of the state than to the improvisations, grey markets, bartering and ingenuity that partly compensated for its failures. Just as an 'informal Brasília', which had no legitimate place in official plans, arose to make the city viable, so did a set of informal practices lying outside the formal command economy – and often outside Soviet law as well – arise to circumvent some of the colossal waste and inefficiencies built into the system. Collectivized agriculture, in other words, never quite operated according to the hierarchical grid of its production plans and procurements.

What seems clear, in the brief account that follows, is that collectivization per se cannot be laid solely at the feet of Stalin, though he bore much responsibility for its exceptional speed and brutality.[38] A collectivized agriculture was always part of the Bolshevik map of the future, and the great procurement struggles of the late 1920s could hardly have had any other outcome in the context of the decision to pursue forced-draft industrialization. The party's high-modernist faith in great collectivist schemes survived long after the desperate improvisations of the early 1930s. That faith, which claimed to be both aesthetic and scientific, is clearly visible in a much later agrarian high-modernist dream: namely, Khrushchev's virgin lands scheme, launched well after Stalin's death and after his crimes during collectivization had been publicly denounced. What is remarkable is how long these beliefs and structures prevailed, in spite of the evidence of their manifold failings.

Round one: The Bolshevik state and the peasantry

> *It sometimes seems to me that if I could persuade everyone to say 'systematize' each time he wanted to say 'liberate' and to say 'mobilization' every time he wanted to say 'reform' or 'progress' I would not have to write long books about government–peasant interaction in Russia.*
>
> George Yaney, *The Urge to Mobilize*

In the particular book quoted above, Yaney was writing about pre-revolutionary Russia, but he could just as easily have been writing about the Bolshevik state. Until 1930, the continuities between the rural policy of the Leninist state and its czarist predecessor are more striking than their differences. There is the same belief in reform from above and in large, modern, mechanized farms as the key to productive agriculture. There is also, alas, the same high level of ignorance about a very complex rural economy coupled, disastrously, with heavy-handed raids on the countryside to seize grain by force. Although the continuities persisted even after the institutional revolution of 1930, what is new about the all-out drive to collectivize is the revolutionary state's willingness to completely remake the institutional landscape of the agrarian sector, and at whatever cost.

The new Bolshevik state faced a rural society that was significantly more opaque, resistant, autonomous and hostile than the one encountered by the czarist bureaucracy. If the czarist officials had provoked massive defiance and evasion in their 'crude Muscovite tribute-collecting methods' during World War I,[39] there was every reason to suspect that the Bolsheviks would have an even harder time squeezing grain from the countryside.

If much of the countryside was hostile to the Bolsheviks, the sentiment was abundantly reciprocated. For Lenin, as we have seen, the Land Decree, which gave to the peasants the land that they had seized, had been a strategic manoeuvre designed to buy rural quiescence while power was consolidated; he had no doubt that peasant smallholdings must eventually be abolished in favour of large, socialized farms. For Trotsky, the sooner what he called 'the Russia of icons and cockroaches' was transformed and 'urbanized', the better. And for many of the newly urbanized, rank-and-file Bolsheviks, the abolition of the 'dark and backward peasant world' was a 'vital part of their own emerging personal and working-class identity'.[40]

The peasantry was virtually terra incognita to the Bolsheviks. At the time of the revolution, the party had throughout Russia a grand total of 494 'peasant' members (most of them probably rural intelligentsia).[41] Most villagers had never seen a Communist, although they may well have heard of the Bolshevik decree confirming peasant ownership of the land that had been seized. The only revolutionary party with any rural following was the Social Revolutionaries, whose populist roots tended to make them unsympathetic to Lenin's authoritarian outlook.

The effects of the revolutionary process itself had rendered rural society more opaque and hence more difficult to tax. There had already been a sweeping seizure of land, dignified, retrospectively, by the inappropriate term 'land reform'. In fact, after the collapse of the offensive into Austria during the war and the subsequent mass desertions, much of the land of the gentry and church, as well as 'crown land', had been absorbed by the peasantry. Rich peasants cultivating independent farmsteads (the 'separators' of the Stolypin reforms) were typically forced back into the village allotments, and rural society was in effect radically compressed. The very rich had been dispossessed, and many of the very poor became smallholders for the first time in their lives. According to one set of figures, the number of landless rural labourers in Russia dropped by half, and the average peasant holding increased by 20 per cent (in the Ukraine, by 100 per cent). A total of 248 million acres was confiscated, almost always by local initiative, from large and small landlords and added to peasant holdings, which now averaged about 70 acres per household.[42]

From the perspective of a tax official or a military procurement unit, the situation was nearly unfathomable. The land-tenure status in each village had changed dramatically. Prior landholding records, if they existed at all, were entirely unreliable as a guide to current land claims. Each village was unique in many respects, and, even if it could in principle have been 'mapped', the population's mobility and military turmoil of the period all but guaranteed that the map would have been made obsolete in six months or sooner. The combination, then, of smallholdings, communal tenure and constant change, both spatial and temporal, operated as an impenetrable barrier to any finely tuned tax system.

Two additional consequences of the revolution in the countryside compounded the difficulties of state officials. Before 1917, large peasant farms and landlord enterprises had produced nearly three-quarters of the grain marketed for domestic use and export. It was this sector of the rural economy that had fed the cities. Now it was gone. The bulk of the remaining cultivators were consuming a much larger share of their own yield. They would not surrender this grain without a fight. The new, more egalitarian distribution of land meant that extracting anything like the czarist 'take' in grain would bring the Bolsheviks in conflict with the subsistence needs of small and middle peasants.[43]

The second and perhaps decisive consequence of the revolution was that it had greatly enhanced the determination and capacity of peasant communities to resist the state. Every revolution creates a temporary power vacuum when the power of the ancien regime has been destroyed but the revolutionary regime has not yet asserted itself throughout the territory. Inasmuch as the Bolsheviks were largely urban and found themselves fighting an extended civil war, the power vacuum in much of the countryside was unusually pronounced. It was the first time, as Orlando Figes reminds us, that the villages, although in straitened circumstances, were free to organize their own affairs.[44] As we have seen, the villagers typically forced out or burned out the gentry, seized the land (including rights to common land and forests), and forced the separators back into the communes. The villages tended to behave as autonomous republics, well disposed to the Reds as long as they confirmed the local 'revolution', but strongly resistant to forced levies of grain, livestock or men from any quarter. In this situation, the fledgling Bolshevik state, arriving as it often did in the form of military plunder, must have been experienced by the peasantry as a reconquest of the countryside by the state – as a brand of colonization that threatened their newly won autonomy.

Given the political atmosphere in rural Russia, even a government having detailed knowledge of the agricultural economy, a local base of support, and a knack for diplomatic tact would have confronted great difficulties. The Bolsheviks lacked all three. A tax system based on income or wealth was possible only with a valid cadastral map and an up-to-date census, neither of which existed. Farm income, moreover, varied greatly with regard to yields and prices from year to year, so any income tax would have had to have been exceptionally sensitive to these conditions in local harvests. Not only did the new state lack the basic information it needed to govern efficiently, it had also largely destroyed the czarist state apparatus of local officials, gentry and specialists in finance and agronomy who had managed, however inadequately, to collect taxes and grain during the war. Above all, the Bolsheviks generally lacked the village-level native trackers who could have helped them to find their way in a hostile and confusing environment. The village Soviets that were supposed to play this role were typically headed by villagers loyal to local interests rather than to the centre. An alternative organ, the Committee of the Rural Poor (*kombedy*), which purported to represent the rural proletariat in local class struggles, was either successfully coopted by the village or locked in often violent conflict with the village soviet.[45]

The inscrutability of the mir to most Bolshevik officials was not simply a result of their urban social origins and the admitted complexity of village affairs. It was also the product of a conscious local strategy, one that had demonstrated its protective value in earlier conflicts with the gentry and the state. The local commune had a long history of underreporting its arable land and overreporting its population in order to appear as poor and untaxable as possible.[46] As a result of such deception in the census of 1917, the arable land in Russia had been underestimated by about 15 per cent. Now, in addition to the woodland, pastures and open land that the peasantry had earlier converted into cropland without reporting it, they had an interest in hiding much of the land they had just seized from the landlords and the gentry. Village committees did, of course, keep records for allocating allotment land, organizing communal plough teams, fixing grazing schedules, and so on, but none of these records was made available either to officials or to the kombedy. A popular saying of the period captures the situation nicely: the peasant 'owned by decree' (that is, the Land Decree) but 'lived secretly'.

How did the hard-pressed state find its way in this labyrinth? Where possible, the Bolsheviks did try to establish large state farms or collective farms. Many of these were 'Potemkin collectives' designed merely to give cover of legitimacy to existing practices. But where they were not a sham, they revealed the political and administrative attractiveness of a radical simplification of the landholding and tax-paying unit in the countryside. Yaney's summary of the logic entailed is impeccable.

> From a technical point of view it was infinitely easier to plough up large units of land without regard for individual claims than it was to identify each family allotment, measure its value in the peasants' traditional terms, and then painfully transpose it from scattered strips into a consolidated farm. Then, too, a capital city administrator could not help but prefer to supervise and tax large productive units and not have to deal with separate farmers… The collective had a dual appeal to authentic agrarian reformers. They represented a social ideal for rhetorical purposes, and at the same time they seemed to simplify the technical problems of land reform and state control.[47]

In the turmoil of 1917–1921, not many such agrarian experiments were possible, and those that were attempted generally failed badly. They were, however, a straw in the wind for the full collectivization campaign a decade later.

Unable to remake the rural landscape, the Bolsheviks turned to the same methods of forced tribute under martial law that had been used by their czarist predecessors during the war. The term 'martial law', however, conveys an orderliness that was absent from actual practice. Armed bands (*otriady*) – some authorized and others formed spontaneously by hungry townsmen – plundered the countryside during the grain crisis of spring and summer 1918, securing whatever they could. Insofar as grain procurement quotas were set at all, they were 'purely mechanical accounting figures originating from an unreliable estimate of arable and assuming a good harvest'. They were, from the beginning, 'fictional and unfulfillable'.[48] The procurement of grain looked more like plunder and theft than delivery and purchase. Over 150 distinct uprisings, by one estimate, erupted against the state's grain seizures. Since the Bolsheviks had, in March 1918, renamed themselves the Communist Party, many of the rebels claimed to be for the Bolsheviks and the Soviets (whom they associated with the Land Decree) and against the Communists. Lenin, referring to the peasant uprisings in Tambov, the Volga and the Ukraine, declared that they posed more of a threat than all the Whites put together. Desperate peasant resistance had in fact all but starved the cities out of existence,[49] and in early 1921, the party, for the first time, turned its guns on its own rebellious sailors and workers in Kronstadt. At this point the beleaguered party beat a tactical retreat, abandoning War Communism and inaugurating the New Economic Policy (NEP), which condoned free trade and small property. As Figes notes, 'Having defeated the White Army, backed by eight Western powers, the Bolshevik government surrendered before its own peasants.'[50] It was a hollow victory. The deaths from the hunger and epidemics of 1921–1922 nearly equalled the toll claimed by World War I and the civil war combined.

Round two: High modernism and procurement

The conjunction of a high-modernist faith in what agriculture should look like in the future and a more immediate crisis of state appropriation helped to spark the all-out drive to collectivization in the winter of 1929–1930. In focusing on just these two issues, we must necessarily leave to others (and they are a multitude) the gripping issues of the human costs of collectivization, the struggle with the 'right' opposition led by Bukharin, and whether Stalin intended to liquidate Ukrainian culture as well as many Ukrainians.

There is no doubt that Stalin shared Lenin's faith in industrial agriculture. The aim of collectivization, he said in May 1928, was 'to transfer from small, backward, and fragmented peasant farms to consolidated, big, public farms, provided with machines, equipped with the data of science, and capable of producing the greatest quantity of grain for the market'.[51]

This dream had been deferred in 1921. There had been some hope that a gradually expanding collective sector in the 1920s could provide as much as one-third of the country's grain needs. Instead, the collectivized sector (both the state farms and the collective farms), which absorbed 10 per cent of the labour force, produced a dismal 2.2 per cent of gross farm production.[52] When Stalin decided on a crash industrialization programme, it was clear that the existing socialist agricultural sector could not provide either the food for a rapidly growing urban workforce or the grain exports necessary to finance the imported technology needed for industrial growth. The middle and rich peasants, many of them newly prosperous since the New Economic Policy, had the grain he needed.

Beginning in 1928, the official requisition policy put the state on a collision course with the peasantry. The mandated delivery price of grain was one-fifth of the market price, and the regime returned to using police methods as peasant resistance stiffened.[53] When the procurements faltered, those who refused to deliver what was required (who, along with anyone else opposing collectivization, were called kulaks, regardless of their economic standing) were arrested for deportation or execution, and all their grain, equipment, land and livestock were seized and sold. The orders sent to those directly in charge of grain procurement specified that they were to arrange meetings of poor peasants to make it seem as if the initiative had come from below. It was in the context of this war over grain, and not as a carefully planned policy initiative, that the decision to force 'total' (*sploshnaia*) collectivization was made in late 1929. Scholars who agree on little else are in accord on this point: the overriding purpose of collectivization was to ensure the seizure of grain. Fitzpatrick begins her study of the collectives with this assertion: 'The main purpose of collectivization was to increase state grain procurements and reduce the peasants' ability to withhold grain from the market. This purpose was obvious to peasants from the start, since the collectivization drive of the winter of 1929–1930 was the culmination of more than two years of bitter struggle between the peasants and the state over grain procurements.'[54] Robert Conquest concurs: 'The collective farms were essentially a chosen mechanism for extracting grain and other products.'[55]

It appears that this was also how the vast majority of the peasantry saw it, judging from their determined resistance and what we know of their views. The seizure of grain threatened their survival. The peasant depicted in Andrei Platonov's novel about collectivization sees how the seizure of grain negates the earlier land reform: 'It's a sly business. First you hand over the land, and then you take away the grain, right down to the last kernel. You can choke on land like that! The muzhik doesn't have anything left from the land except the horizon. Who are you fooling?'[56] At least as threatening was the loss of what little margin of social and economic autonomy the peasantry had achieved since the revolution. Even poor peasants were afraid of collectivization, because 'it would involve giving up one's land and implements and working with other families, under orders, not temporarily, as in the army, but forever – it means the barracks for life.'[57] Unable to rely on any significant rural support, Stalin dispatched 25,000 'plenipotentiaries' (party members) from the towns and factories 'to destroy the peasant commune and replace it by a collective economy subordinate to the state', whatever the cost.[58]

Authoritarian high-modernist theory and the practice of serfdom

If the move to 'total' collectivization was directly animated by the party's determination to seize the land and the crops sown on it once and for all, it was a determination filtered through a high-modernist lens. Although the Bolsheviks might disagree about means, they did think they knew exactly what modern agriculture should look like in the end; their understanding was as much visual as scientific. Modern agriculture was to be large in scale, the larger the better; it was to be highly mechanized and run hierarchically along scientific, Taylorist principles. Above all, the cultivators were to resemble a highly skilled and disciplined proletariat, not a peasantry. Stalin himself, before practical failures discredited a faith in colossal projects, favoured collective farms ('grain factories') of 125,000 to 250,000 acres, as in the American-assisted scheme described earlier.[59]

The Utopian abstraction of the vision was matched, on the ground, by wildly unrealistic planning. Given a map and a few assumptions about scale and mechanization, a specialist could devise a plan with little reference to local knowledge and conditions. A visiting agricultural official wrote back to Moscow from the Urals in March 1930 to complain that, 'on the instruction of the Raion Executive

Committee, twelve agronomists have been sitting for twenty days composing an operational-production plan for the non-existent raion commune without ever leaving their offices or going out into the field'.[60] When another bureaucratic monstrosity in Velikie Lukie in the west proved unwieldy, the planners simply reduced the scale without sacrificing abstraction. They divided the 80,000-hectare scheme into 32 equal squares of 2500 hectares each, with one square constituting a kolkhoz. 'The squares were drawn on a map without any reference to actual villages, settlements, rivers, hills, swamps or other demographic and topological characteristics of the land.'[61]

Semiotically, we cannot understand this modernist vision of agriculture as an isolated ideological fragment. It is always seen as the negation of the existing rural world. A kolkhoz is meant to replace a mir or village, machines to replace horse-drawn ploughs and hand labour, proletarian workers to replace peasants, scientific agriculture to replace folk tradition and superstition, education to replace ignorance and *malokulturnyi*, and abundance to replace bare subsistence. Collectivization was meant to spell the end of the peasantry and its way of life. The introduction of a socialist economy entailed a cultural revolution as well; the 'dark' narod, the peasants who were perhaps the great remaining, intractable threat to the Bolshevik state, were to be replaced by rational, industrious, de-Christianized, progressive-thinking kolkhoz workers.[62] The scale of collectivization was intended to efface the peasantry and its institutions, thereby narrowing the gulf between the rural and urban worlds. Underlying the whole plan, of course, was the assumption that the great collective farms would operate like factories in a centralized economy, in this case fulfilling state orders for grain and other agricultural products. As if to drive the point home, the state confiscated roughly 63 per cent of the entire harvest in 1931.

From a central planner's perspective, one great advantage of collectivization is that the state acquired control over how much of each crop was sown. Starting with the state's needs for grains, meat, dairy products and so on, the state could theoretically build those needs into its instructions to the collective sector. In practice, the sowing plans imposed from above were often wholly unreasonable. The land departments, which prepared the plans, knew little about the crops they were mandating, the inputs needed to grow them locally, or local soil conditions. Nevertheless, they had quotas to fill, and fill them they did. When, in 1935, A. Iakovlev, the head of the Central Committee's agricultural department, called for collective farms to be managed by 'permanent cadres' who 'genuinely knew their fields', he implied that the present incumbents did not.[63] We catch a glimpse of the disasters from the Great Purges of 1936–1937, when a certain amount of peasant criticism of kolkhoz officials was briefly encouraged in order to detect 'wreckers'. One kolkhoz was instructed to plough meadows and open land, without which they could not have fed their livestock. Another received sowing orders that doubled the previous acreage allotted for hay fields by taking in private plots and quicksands.[64]

The planners clearly favoured monoculture and a far-reaching, strict division of labour. Entire regions, and certainly individual *kolkhozy*, were increasingly specialized, producing only, say, wheat, livestock, cotton or potatoes.[65] In the case of livestock production, one kolkhoz would produce fodder for beef cattle or hogs while another would raise and breed them. The logic behind kolkhoz and regional specialization was roughly comparable to the logic behind functionally specific urban zones. Specialization reduced the number of variables that agronomists had to consider; it also increased the administrative routinization of work and hence the power and knowledge of central officials.

Procurement followed a comparable centralizing logic. Starting with the needs of the plan and a usually unreliable estimate of the harvest, a series of quotas for every oblast, *raion* and kolkhoz was mechanically derived. Each kolkhoz then claimed that its quota was impossible to fulfil and appealed to have it lowered. Actually meeting a quota, they knew from bitter experience, only raised the ante for the next round of procurements. In this respect collective farmers were in a more precarious situation than industrial workers, who still received their wages and ration cards whether or not the factory met its quota. For the *kolkhozniki*, however, meeting the quota might mean starvation. Indeed, the great famine of 1933–1934 can only be called a collectivization and procurement famine. Those who were tempted to make trouble risked running afoul of a more grisly quota: the one for kulaks and enemies of the state.

For much of the peasantry, the authoritarian labour regime of the kolkhoz seemed not only to jeopardize their subsistence but to revoke many of the freedoms they had won since their emancipation in 1861. They compared collectivization to the serfdom their grandparents remembered. As one early sovkhoz worker put it, 'The *sovkhozy* are always forcing the peasants to work; they make the peasants weed their fields. And they don't even give us bread or water. What will come of all this? It's like *barschina* [feudal labour dues] all over again.'[66] The peasants began to say that the acronym for the Ail-Union Communist Party – VKP – stood for *vtoroe krepostnoe pravo*, or 'second serfdom'.[67] The parallel was not a mere figure of speech; the resemblances to serfdom were remarkable.[68] The kolkhoz members were required to work on the state's land at least half-time for wages, in cash or kind, that were derisory. They depended largely on their own small private plots to grow the food they needed (other than grain), although they had little free time to cultivate their gardens.[69] The quantity to be delivered and price paid for kolkhoz produce was set by the state. The kolkhozniki owed annual corvée labour dues for roadwork and cartage. They were obliged to hand over quotas of milk, meat, eggs and so on from their private plots. The collective's officials, like feudal masters, were wont to use kolkhoz labour for their private sidelines and had, in practice if not in law, the arbitrary power to insult, beat or deport the peasants. As they were under serfdom, they were legally immobilized. An internal passport system was reintroduced to clear the cities of 'undesirable and unproductive residents' and to make sure that the peasantry did not flee. Laws were passed to deprive the peasantry of the firearms they used for hunting. Finally, the kolkhozniki living outside the village nucleus (khutor dwellers), often on their old farmsteads, were forcibly relocated, beginning in 1939. This last resettlement affected more than half a million peasants.

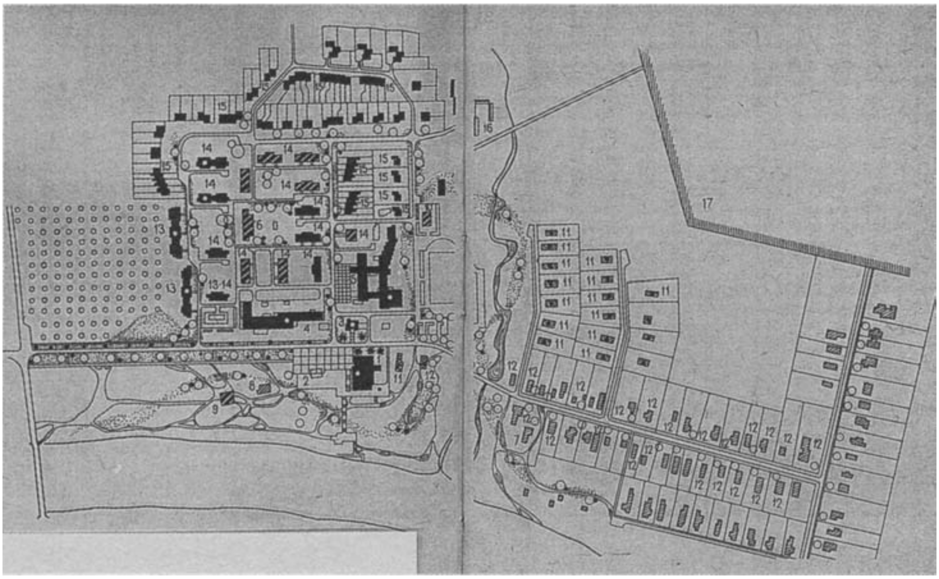
The resulting labour rules, property regime and settlement pattern did in fact resemble a cross between plantation or estate agriculture on one hand and feudal servitude on the other.

As a vast, state-imposed blueprint for revolutionary change, collectivization was at least as notable for what it destroyed as for what it built. The initial intent of collectivization was not just to crush the resistance of well-to-do peasants and grab their land; it was also to dismantle the social unit through which that resistance was expressed: the mir. The peasant commune had typically been the vehicle for organizing land seizures during the revolution, for orchestrating land use and grazing, for managing local affairs generally, and for opposing procurements.[70] The party had every reason to fear that if the collectives were based on the traditional village, they would simply reinforce the basic unit of peasant resistance. Hadn't the village Soviets quickly escaped the state's control? Huge collectives, then, had the decided advantage of bypassing village structures altogether. They could be run by a board consisting of cadres and specialists. If the giant kolkhoz was then divided into sections, one specialist could be named manager of each, '"*like the bailiffs in the old days*" [of serfdom] as [one] … report wryly noted'.[71] Eventually, except in frontier areas, practical considerations prevailed and a majority of the kolkhozy coincided roughly with the earlier peasant commune and its lands.

The kolkhoz was not, however, just window dressing hiding a traditional commune. Almost everything had changed. All the focal points for an autonomous public life had been eliminated. The tavern, rural fairs and markets, the church and the local mill disappeared; in their places stood the kolkhoz office, the public meeting room, and the school. Nonstate public spaces gave way to the state spaces of government agencies, albeit local ones.

The concentration, legibility and centralization of social organization and production can be seen in the map of the state farm at Verchnyua Troitsa (Upper Trinity) in Tver Oblast (Figure 14.1).[72] Much of the old village has been removed from the centre and relocated on the outskirts (legend reference 11).[73] Two-story apartment houses containing 16 flats each have been clustered near the centre (legend references 13, 14, 15; see also Figure 14.2), while the local administration and trade centre, school and community building, all public institutions run by the state, lie close to the centre of the new grid. Even allowing for the exaggerated formalism of the map, the state farm is a far cry from the sprawl and autonomous institutional order of the precollectivized village; a photograph showing the old-style housing and a lane illustrates the stark visual contrast (see Figure 14.3).

Compared to Haussmann's retrofitting of the physical geography of Paris to make it legible and to facilitate state domination, the Bolsheviks' retrofitting of rural Russia was far more thoroughgoing. In place of an opaque and often obstinate mir, it had fashioned a legible kolkhoz. In place of myriad small farms, it had created a single, local economic unit.[74] With the establishment of hierarchical state farms, a quasi-autonomous petite bourgeoisie was replaced with dependent employees. In place, therefore, of an agriculture in which planting, harvesting and marketing decisions were in the hands of individual households, the party-state



1, community centre; *2*, monument; *3*, hotel; *4*, local administration and trade centre; *5*, school; *6*, kindergarten; *7–8*, museums; *9*, shop; *10*, bathhouse; *11*, old wooden house moved from new construction area; *12*, old village; *13–15*, two- and three-storey houses; *16*, garage (private); and *17*, agricultural sites (farm, storage, water tower and so on)

Figure 14.1 *Plan of the state farm at Verchnyua Troitsa (Upper Trinity) in Tver Oblast*

had built a rural economy where all these decisions would be made centrally. In place of a peasantry that was technically independent, it had created a peasantry that was directly dependent on the state for combines and tractors, fertilizer and seeds. In place of a peasant economy whose harvests, income and profits were well-nigh indecipherable, it had created units that were ideal for simple and direct appropriation. In place of a variety of social units with their own unique histories and practices, it had created homologous units of accounting that could all be fitted into a national administrative grid. The logic was not unlike the management scheme at McDonald's: modular, similarly designed units producing similar products, according to a common formula and work routine. Units can easily be duplicated across the landscape, and the inspectors coming to assess their operations enter legible domains which they can evaluate with a single checklist.

Any comprehensive assessment of 60 years of collectivization would require both archival material only now becoming available and abler hands than my own. What must strike even a casual student of collectivization, however, is how it largely failed in *each* of its high-modernist aims, despite huge investments in machinery, infrastructure and agronomic research. Its successes, paradoxically, were in the domain of traditional statecraft. The state managed to get its hands on enough grain to push rapid industrialization, even while contending with staggering inefficiencies,

Figure 14.2 *At Verchnyua Troitsa, one of the new village's two-storey houses, each containing 16 flats*

stagnant yields and ecological devastation.[75] The state also managed, at great human cost, to eliminate the social basis of organized, public opposition from the rural population. On the other hand, the state's capacity for realizing its vision of large, productive, efficient, scientifically advanced farms growing high-quality products for market was virtually nil.

The collectives that the state had created manifested in some ways the facade of modern agriculture without its substance. The farms *were* highly mechanized (by world standards), and they *were* managed by officials with degrees in agronomy and engineering. Demonstration farms really did achieve large yields, although often at prohibitive costs.[76] But in the end none of this could disguise the many failures of Soviet agriculture. Only three sources of these failures are noted here, because they will concern us later.[77] First, having taken from the peasants both their (relative) independence and autonomy as well as their land and grain, the state created a class of essentially unfree labourers who responded with all the forms of foot-dragging and resistance practised by unfree labourers everywhere. Second, the unitary administrative structure and imperatives of central planning created a clumsy machine that was utterly unresponsive to local knowledge or to local conditions. Finally, the Leninist political structure of the Soviet Union gave agriculture officials little or no incentive to adapt to, or negotiate with, its rural subjects. The very capacity of the state to essentially re-enserf rural producers, dismantle their institutions and impose its will, in the crude sense of appropriation,

Figure 14.3 *Houses along a lane in the old village at Verchnyua Troitsa*

goes a long way toward explaining the state's failure to realize anything but a simulacrum of the high-modernist agriculture that Lenin so prized.

State Landscapes of Control and Appropriation

Drawing on the history of Soviet collectivization, I shall now venture a few more frankly speculative ideas about the institutional logic of authoritarian high modernism. Then I shall suggest a way of grasping why such massive social bulldozing may have worked tolerably well for some purposes but failed dismally for others.

The headlong drive to collectivization was animated by the short-term goal of seizing enough grain to push rapid industrialization.[78] Threats and violence had worked, up to a point, for the harvests of 1928 and 1929, but each annual turn of the screw elicited more evasion and resistance from the peasantry. The bitter fact was that the Soviet state faced an exceptionally diverse population of commune-based smallholders whose economic and social affairs were nearly unintelligible to the centre. These circumstances offered some strategic advantages to a peasantry waging a quiet guerrilla war (punctuated by open revolt) against state claims. The state, under the existing property regime, could only look forward to a bruising struggle for grain each year, with no assurance of success.

Stalin chose this moment to strike a decisive blow. He imposed a designed and legible rural landscape that would be far more amenable to appropriation, control and central transformation. The social and economic landscape he had in mind was of course the industrial model of advanced agriculture – large, mechanized farms run along factory lines and coordinated by state planning.

It was a case of the 'newest state' meeting the 'oldest class' and attempting to remake it into some reasonable facsimile of a proletariat. Compared to the peasantry, the proletariat was already relatively more legible as a class, and not just because of its central place in Marxist theory. The proletariat s work regimen was regulated by factory hours and by man-made techniques of production. In the case of new industrial projects like the great steel complex at Magnitogorsk, the planners could start virtually from zero, as with Brasília. The peasants, on the other hand, represented a welter of small, individual household enterprises. Their settlement pattern and social organization had a historical logic far deeper than that of the factory floor.

One purpose of collectivization was to destroy these economic and social units, which were hostile to state control, and to force the peasantry into an institutional straitjacket of the state's devising. The new institutional order of collective farms would now be compatible with the state's purposes of appropriation and directed development. Given the quasi-civil war conditions of the countryside, the solution was as much a product of military occupation and 'pacification' as of 'socialist transformation'.[79]

It is possible, I believe, to say something more generally about the 'elective affinity' between authoritarian high modernism and certain institutional arrangements.[80]

What follows is rather crude and provisional, but it will serve as a point of departure. High-modernist ideologies embody a doctrinal preference for certain social arrangements. *Authoritarian* high-modernist *states*, on the other hand, take the next step. They attempt, and often succeed, in imposing those preferences on their population. Most of the preferences can be deduced from the criteria of legibility, appropriation and centralization of control. To the degree that the institutional arrangements can be readily monitored and directed from the centre and can be easily taxed (in the broadest sense of taxation), then they are likely to be promoted. The implicit goals behind these comparisons are not unlike the goals of premodern statecraft.[81] Legibility, after all, is a prerequisite of appropriation as well as of authoritarian transformation. The difference, and it is a crucial one, lies in the wholly new scale of ambition and intervention entertained by high modernism.

The principles of standardization, central control and synoptic legibility to the centre could be applied to many other fields; those noted in the accompanying table are only suggestive. If we were to apply them to education, for example, the most illegible educational system would be completely informal, nonstandardized instruction determined entirely by local mutuality. The most legible educational system would resemble Hippolyte Taine's description of French education in the 19th century, when 'the Minister of Education could pride himself, just by looking at his watch, which page of Virgil all schoolboys of the Empire were annotating at that exact moment'.[82] A more exhaustive table would replace the dichotomies with more elaborate continua (open commons landholding, for example, is less legible and taxable than closed commons landholding, which in turn is less legible than private freeholding, which is less legible than state ownership). It is no coincidence that the more legible or appropriable form can more readily be converted into a source of rent – either as private property or as the monopoly rent of the state.

The Limits of Authoritarian High Modernism

When are high-modernist arrangements likely to work and when are they likely to fail? The abject performance of Soviet agriculture as an efficient producer of foodstuffs was, in retrospect, 'overdetermined' by many causes having little to do with high modernism per se: the radically mistaken biological theories of Trofim Lysenko, Stalin's obsessions, conscription during World War II and the weather. And it is apparent that centralized high-modernist solutions can be the most efficient, equitable and satisfactory for many tasks. Space exploration, the planning of transportation networks, flood control, airplane manufacturing and other endeavours may require huge organizations minutely coordinated by a few experts. The control of epidemics or of pollution requires a centre staffed by experts receiving and digesting standard information from hundreds of reporting units.

On the other hand, these methods seem singularly maladroit at such tasks as putting a really good meal on the table or performing surgery. This issue is addressed

Table 14.1 *Legibility of social groups, institutions and practices*

	Illegible	*Legible*
Settlements	• Temporary encampments of hunter-gatherers, nomads, slash-and-burn cultivators, pioneers and gypsies • Unplanned cities and neighbourhoods: Bruges in 1500, medina of Damascus, Faubourg Saint-Antoine, Paris, in 1800	• Permanent villages, estates and plantations of sedentary peoples • Planned grid cities and neighbourhoods: Brasília, Chicago
Economic units	• Small property, petite bourgeoisie • Small peasant farms • Artisanal production • Small shops • Informal economy, 'off the books'	• Large property • Large farms • Factories (proletariat) • Large commercial establishments • Formal economy, 'on the books'
Property regimes	• Open commons, communal property • Private property • Local records	• Collective farms • State property • National cadastral survey
Technical and resource organizations		
Water	• Local customary use, local irrigation societies	• Centralized dam, irrigation control
Transportation	• Decentralized webs and networks	• Centralized hubs
Energy	• Cow pats and brushwood gathered locally or local electric generating stations	• Large generating stations in urban centres
Identification	• Unregulated local naming customs • No state documentation of citizens	• Permanent patronyms • National system of identification cards, documents or passports

at length in Scott (1998, ch. 8),[83] but some valuably suggestive evidence can be gleaned from Soviet agriculture. If we think of particular crops, it is apparent that collective farms were successful at growing some crops, especially the major grains: wheat, rye, oats, barley and maize. They were notably inefficient at turning out other products, especially fruits, vegetables, small livestock, eggs, dairy products and flowers. Most of these crops were supplied from the minuscule private plots of the kolkhoz members, even at the height of collectivization.[84] The systematic differences between these two categories of crops helps to explain why their institutional setting might vary.

Let us take wheat as an example of what I will call a 'proletarian crop' and compare it with red raspberries, which I think of as the ultimate 'petit-bourgeois crop'. Wheat lends itself to extensive large-scale farming and mechanization. One might say that wheat is to collectivized agriculture what the Norway spruce is to centrally managed, scientific forestry. Once planted, it needs little care until harvest, when a combine can cut and thresh the grain in one operation and then blow it into trucks bound for granaries or into railroad cars. Relatively sturdy in the ground, wheat remains sturdy once harvested. It is relatively easy to store for extended periods with only small losses to spoilage. The red raspberry bush, on the other hand, requires a particular soil to be fruitful; it must be pruned annually; it requires more than one picking, and it is virtually impossible to pick by machine. Once packed, raspberries last only a few days under the best conditions. They will spoil within hours if packed too tightly or if stored at too high a temperature. At virtually every stage the raspberry crop needs delicate handling and speed, or all is lost.

Little wonder, then, that fruits and vegetables – petit-bourgeois crops – were typically not grown as kolkhoz crops but rather as side-lines produced by individual households. The collective sector in effect ceded such crops to those who had the personal interest, incentive and horticultural skills to grow them successfully. Such crops can, in principle, be grown by huge centralized enterprises as well, but they must be enterprises that are elaborately attentive to the care of the crops and to the care of the labour that tends them. Even where such crops are grown on large farms, the farms tend to be family enterprises of smaller size than wheat farms and are insistent on a stable, knowledgeable workforce. In these situations, the small family enterprise has, in the terms of neoclassical economics, a comparative advantage.

Another way in which wheat production is different from raspberry production is that the growing of wheat involves a modest number of routines that, because the grain is robust, allow some slack or play. The crop will take some abuse. Raspberry growers, because successful cultivation of their crop is complex and the fruit is delicate, must be adaptive, nimble and exceptionally attentive. Successful raspberry growing requires, in other words, a substantial stock of local knowledge and experience.

Notes

1 The best source for a discussion about Soviet high modernism is probably Richard Stites, *Revolutionary Dreams: Utopian Vision and Experimental Life in the Russian Revolution* (New York: Oxford University Press, 1989). Its generous bibliography appears to cover most of the available sources.

2 This inference, we know, is not a distortion of the doctrines of liberalism. J. S. Mill, whose credentials as a liberal son of the Enlightenment are not in doubt, considered backwardness a sufficient justification for placing authoritarian powers in the hands of a modernizer. See Ernest Gellner, 'The Struggle to Catch Up,' *Times Literary Supplement*, 9 December 1994, p. 14. For a more detailed argument along these lines, see also Jan P. Nederveen Pieterse and Bhikhu Parekh, eds., *The Decolonization of the Imagination: Culture, Knowledge, and Power* (London: Zed Press, 1995).

3 Stites, *Revolutionary Dreams*, p19. Engels expressed his disdain for Communist Utopian schemes like these by calling them 'barracks Communism'.

4 One could say that Catherine the Great, being Prussian born and an avid correspondent with several of the Encylopedists, including Voltaire, came by her mania for rational order honestly.

5 Sheila Fitzpatrick, *The Russian Revolution* (Oxford: Oxford University Press, 1982), p. 119. The term 'gigantomania' was, I believe, also in use in the Soviet Union. The ultimate failure of most of the USSR's great schemes is in itself an important story, the significance of which was captured epigrammatically by Robert Conquest, who observed that 'the end of the Cold War can be seen as the defeat of Magnitogorsk by Silicon Valley' ('Party in the Dock,' *Times Literary Supplement*, 6 November 1992, p. 7). For an industrial, cultural and social history of Magnitogorsk, see Stephen Kotkin, *Magnetic Mountain: Stalinism as a Civilization* (Berkeley: University of California Press, 1995).

6 An interesting parallel can be seen in the French countryside following the Revolution, when campaigns called for 'de-Christianization' and offered associated secular rituals.

7 Stites, *Revolutionary Dreams*, p. 119. See also Vera Sandomirsky Dunham, *In Stalin's Time: Middle-Class Values in Soviet Fiction* (Cambridge: Cambridge University Press, 1976), for how, under Stalin, this austerity was transformed into opulence.

8 Stites, 'Festivals of the People,' chap. 4 of *Revolutionary Dreams*, pp. 79–97.

9 Ibid., p. 95. Through Sergey Eisenstein's films, these public theatrical reenactments are the visual images that remain embedded in the consciousness of many of those who were not participants in the actual revolution.

10 Composers and filmmakers were also expected to be 'engineers of the soul'.

11 Quoted in Stites, *Revolutionary Dreams*, p. 243.

12 Lenin, almost certainly influenced by another of his favourite books, Campanella's *City of the Sun*, wanted public sculptures of revolutionaries, complete with inspiring inscriptions, to be erected throughout the city: a propaganda of monuments. See Anatoly Lunacharsky, 'Lenin and Art,' *International Literature* 5 (May 1935): 66–71.

13 Stites, *Revolutionary Dreams*, p. 242.

14 This entire section is based on chaps. 2, 4 and 6 of a remarkable forthcoming book by Deborah Fitzgerald, *Yeoman No More: The Industrialization of American Agriculture*, to which I am greatly indebted. The chapter and page numbers that follow refer to the draft manuscript.

15 Ibid., chap. 2, p. 21.

16 As many commentators have emphasized, this redesigning of work processes wrested the control of production from skilled artisans and labourers and placed it in the hands of management, whose ranks and prerogatives grew as the labour force was 'de-skilled'.

17 Around 1920, much of the market for agricultural machinery made by US manufacturers was not in the United States, where farm sizes were still relatively small, but outside the country, in such places as Canada, Argentina, Australia and Russia, where farms were considerably larger. Fitzgerald, *Yeoman No More*, chap. 2, p. 31.

18 For a fascinating and more complete account of the Campbell enterprise, see 'The Campbell Farm Corporation', chap. 5, ibid. It's worth adding here that the economic depression for agriculture in the United States began at the end of World War I, not in 1930. The time was thus ripe for bold experimentation, and cost of buying or leasing land was cheap.

19 Wheat and flax are, in the terminology developed later in this chapter, 'proletarian' crops as opposed to 'petit-bourgeois' crops.

20 Fitzgerald, *Yeoman No More*, chap. 4, pp. 15–17.

21 See above, nn. 14 and 18.

22 Another such farm, and one with direct links to New Deal experimentation in the 1930s, was the Fairway Farms Corporation. Founded in 1924 by M. L. Wilson and Henry C. Taylor, both of whom were trained in institutional economics at the University of Wisconsin, the corporation was designed to turn landless farmers into scientific, industrial farmers. The capital for the new enterprise came, through intermediaries, from John D. Rockefeller. 'Fair Way' Farms would become the model for many of the New Deal's more ambitious agricultural programmes as Wilson, Taylor and many of their progressive colleagues in Wisconsin moved to influential positions in Washington under Roosevelt. A more searching account of the connection is in Jess Gilbert and Ellen R. Baker, 'Wisconsin Economists and New Deal Agricultural Policy: The Legacy of Progressive Professors' (unpublished paper, 1995). The 1920s were a fertile time for agricultural experimentation, partly because the economic slump for agricultural commodities after World War I prompted policy initiatives designed to alleviate the crisis.

23 Fitzgerald, *Yeoman No More*, chap. 4, pp. 18–27. For an account of industrial farming in Kansas and its link to the ecological disaster known as the dust bowl, see Donald Worster, *Dust Bowl: The Southern Plains in the 1930s* (New York: Oxford University Press, 1979).

24 Fitzgerald, *Yeoman No More*, chap. 4, p. 33. The plan's outline can be found in Mordecai Ezekial and Sherman Johnson, 'Corporate Farming: The Way Out?' *New Republic*, 4 June 1930, pp. 66–68.

25 Michael Gold, 'Is the Small Farmer Dying?' *New Republic*, 7 October 1931, p. 211, cited in Fitzgerald, *Yeoman No More*, chap. 2, p. 35.

26 Ibid., chap. 6, p. 13. See also Deborah Fitzgerald, 'Blinded by Technology: American Agriculture in the Soviet Union, 1928–1932,' *Agricultural History* 70, no. 3 (Summer 1996): 459–86.

27 Enthusiastic visitors included the likes of John Dewey, Lincoln Steffens, Rexford Tugwell, Robert LaFollette, Morris Llewellyn Cooke (at the time the foremost exponent of scientific management in the United States), Thurman Arnold, and, of course, Thomas Campbell, who called the Soviet experiment 'the biggest farming story the world has ever heard'. Typical of the praise for Soviet plans for a progressive, modernized rural life was this appraisal by Belle LaFollette, the wife of Robert LaFollette: 'If the Soviets could have their way, all land would be cultivated by tractors, all the villages lighted by electricity, each community would have a central house serving for the purpose of school, library, assembly hall, and theatre. They would have every convenience and advantage which they plan for the industrial workers in the city' (quoted in Lewis S. Feuer, 'American Travelers to the Soviet Union, 1917–1932: The Formation of a Component of New Deal Ideology,' *American Quarterly* 14 [Spring 1962]: 129). See also David Caute, *The Fellow Travellers: Intellectual Friends of Communism*, rev. edn (New Haven: Yale University Press, 1988).

28 Feuer, 'American Travelers to the Soviet Union,' pp. 119–49, cited in Fitzgerald, *Yeoman No More*, chap. 6, p. 4.

29 Fitzgerald, *Yeoman No More*, chap. 6, p. 6.

30 Ibid., p. 37.

31 Ibid., p. 14.

32 Ibid., p. 39 (emphasis added).

33 Quoted in Robert Conquest, *The Harvest of Sorrow: Soviet Collectivization and the Terror-Famine* (New York: Oxford University Press, 1986), p. 232. An even more explicit recognition that this was a 'war' appears in this statement by M. M. Khateyevich: 'A ruthless struggle is going on

between the peasantry and our regime. It's a struggle to the death. This year was a test of our strength and their endurance. It took a famine to show them who was master here. It has cost millions of lives, but the collective farm system is here to stay, we've won the war' (quoted in ibid., p. 261).

34 The so-called Great Leap Forward in China was at least as deadly and may be analysed in comparable terms. I have chosen to concentrate on Soviet Russia largely because events there occurred some 30 years before the Great Leap Forward and hence have received much more scholarly attention, especially during the past seven years, when the newly opened Russian archives have greatly expanded our knowledge. For a recent popular account of the Chinese experience, see Jasper Becker, *Hungry Ghosts: China's Secret Famine* (London: John Murray, 1996).

35 In cases where yields were high among state farms and show projects, they were typically achieved with such costly inputs of machinery, fertilizers, pesticides and herbicides that the results were economically irrational.

36 For an exceptionally perceptive account of collectivization and its results, see Moshe Lewin, *The Making of the Soviet System: Essays in the Social History of Interwar Russia* (New York: Pantheon, 1985), especially part 2, pp. 89–188.

37 I use the term 'lumpen' here to designate a huge floating population of great variety and shifting occupations. Although Marx and Lenin always used the term scornfully, implying both criminal tendencies and political opportunism, I intend no such denigration.

38 Stalin, it is now believed, was personally responsible for drafting in August 1932 a secret decree branding all those who withheld grain, now declared to be 'sacred and untouchable' state property, as 'enemies of the people' and ruling that they should be summarily arrested and shot. The same Stalin, at the Second Congress of Outstanding Kolkhozniks in 1935, championed the retaining of adequate private plots: 'The majority of kolkhozniks want to plant an orchard, cultivate a vegetable garden or keep bees. The kolkhozniks want to live a decent life, and for that this 0.12 hectares is not enough. We need to allocate a quarter to half a hectare, and even as much as one hectare in some districts' (quoted in Sheila Fitzpatrick, *Stalin's Peasants: Resistance and Survival in the Russian Village After Collectivization* [New York: Oxford University Press, 1995], pp. 73, 122).

39 Ibid., p. 432.

40 Orlando Figes, 'Peasant Aspirations and Bolshevik State-Building in the Countryside, 1917–1925,' paper presented at the Program in Agrarian Studies, Yale University, New Haven, 14 April 1995, p. 24. Figes also links these views to socialist tracts that date from at least the 1890s and that pronounced the peasantry doomed by economic progress (p. 28).

41 R. W. Davies, *The Socialist Offensive: The Collectivisation of Soviet Agriculture, 1929–1930* (London: Macmillan, 1980), p. 51.

42 Conquest, *Harvest of Sorrow*, p. 43.

43 Also, the collapse of urban enterprises, which would normally have supplied consumer goods and farm implements to the rural areas, meant that there was less incentive for the peasantry to sell grain in order to make purchases in the market.

44 See Orlando Figes's remarkably perceptive and detailed book, *Peasant Russia, Civil War: The Volga Countryside in Revolution, 1917–1921* (Oxford: Clarendon Press, 1989). Even near revolutions create a similar vacuum. Following the 1905 revolution, it took the czarist government nearly two years to reassert its control over the countryside.

45 The relative unity of the village was itself enhanced by the revolutionary process. The richest landlords had left or been burned out, and the poorest, landless families had typically gotten some land. As a result, the villagers were more socioeconomically similar and therefore more likely to respond similarly to external demands. Since many of the independent farmers were pressured to return to the commune, they were now dependent on the entire village for their household's allotment of the communal lands. Thus it is not hard to understand why, in those instances where the kombedy was an instrument of Bolshevik policy, it faced determined opposition from the more

representative village soviet. 'One government official from Samara Province claimed, with conscious irony, that the conflicts between the kombedy and the Soviets represented the main form of "class struggle" in the rural areas during this period' (ibid., p. 197). In the larger villages, some support for Bolshevik agrarian plans could be found among educated youth, schoolteachers and veterans who had become Bolsheviks while serving with the Red Army during World War I or the civil war (and who might have imagined themselves occupying leading roles in the new collective farms). See Figes, 'Peasant Aspirations and Bolshevik State-Building'.

46 There was also a tendency to hide income from craft, artisanal and trading sidelines as well as 'garden' crops. During this same period, it should be added, insufficient resources – manpower, draft animals, manure and seed – meant that some of the arable either could not be planted or could only produce yields that were far lower than usual.

47 Yaney, *The Urge to Mobilize*, pp. 515–516. For Yaney, the continuity in aspirations from what he terms 'messianic social agronomists' under the czarist regime to the Bolshevik collectivizers was striking. In a few cases, they were the same people.

48 Figes, *Peasant Russia, Civil War*, p. 250.

49 Hunger and flight from the towns had reduced the number of urban industrial workers from 3.6 million in 1917 to no more than 1.5 million in 1920 (Fitzpatrick, *The Russian Revolution*, p. 85).

50 Figes, *Peasant Russia, Civil War*, p. 321.

51 Quoted in Fitzpatrick, *Stalin's Peasants*, p. 39.

52 In theory, at least, the most 'advanced' were the state farms – the proletarian, industrial, collective farms in which workers were paid wages and no private plots were allowed. These farms also received the bulk of state investment in machinery in the early years. For production statistics, see Davies, *The Socialist Offensive*, p. 6.

53 Ibid., pp. 82–113.

54 Fitzpatrick, *Stalin's Peasants*, p. 4.

55 Conquest, *Harvest of Sorrow*, p. 183.

56 Andrei Platonov, *Chevengur*, trans. Anthony Olcott (Ann Arbor: Ardis, 1978).

57 M. Hindus, *Red Breed* (London, 1931), quoted in Davies, *The Socialist Offensive*, p. 209.

58 Davies, *The Socialist Offensive*, p. 205.

59 The size of collective farms remained enormous, even by American standards, throughout the Soviet period. Fred Pryor calculates that in 1970 the average state farm comprised more than 100,000 acres, while the average collective farm comprised over 25,000 acres. The state farms were greatly favoured in access to inputs, machinery and other subsidies. See Frederick Pryor, *The Red and the Green: The Rise and Fall of Collectivized Agriculture in Marxist Regimes* (Princeton: Princeton University Press, 1992), table 7, p. 34.

60 Fitzgerald, *Stalin's Peasants*, p. 105.

61 Ibid., pp. 105–106. One imagines that the soils and existing cropping patterns were also ignored.

62 As the Bolsheviks explained, 'The kolkhozy are the only means by which the peasantry can escape from poverty and darkness' (Davies, *The Socialist Offensive*, p. 282). Perhaps the best visual images of the culturally transforming properties of electricity, machinery and collectivization are found in Sergey Eisenstein's film *The General Line*, a veritable technological romance set in rural Russia. The film masterfully conveys the Utopian aspirations of high modernism by contrasting the plodding dark narod with his horse and scythe with images of electric cream separators, tractors, mowing machines, engines, skyscrapers, engines and airplanes.

63 Fitzpatrick, *Stalin's Peasants*, p. 194.

64 Ibid., pp. 306–309.

65 For an account of how an even more extreme version of regional specialization was imposed on the Chinese countryside, in violation of local soil and climatological conditions, see Ralph Thaxton, *Salt of the Earth: The Political Origins of Peasant Protest and Communist Revolution in China* (Berkeley: University of California Press, 1997).

66 Figes, *Peasant Russia, Civil War*, p. 304. The analogy took concrete form in many of the early revolts against collectivization, during which the peasantry destroyed all the records of labour dues, crop deliveries, debts, and so on, just as they had under serfdom.

67 Conquest, *Harvest of Sorrow*, p. 152.

68 The resemblances to serfdom are spelled out in some detail in Fitzgerald, *Stalin's Peasants*, pp. 128–139. For a careful and informed discussion of serfdom and comparisons to slavery, see Peter Kolchin, *Unfree Labor: American Slavery and Russian Serfdom* (Cambridge: Harvard University Press, 1987).

69 For an astute account by a Soviet journalist and human rights campaigner in the 1980s, indicating that the basic pattern had not greatly changed, see Lev Timofeev, *Soviet Peasants, or The Peasants' Art of Starving*, trans. Jean Alexander and Alexander Zaslavsky, ed. Armando Pitassio and Alexander Zaslavsky (New York: Telos Press, 1985).

70 I am persuaded by the historical accounts that characterize the mir as the peasantry's adaptation to a gentry and state that treated it as a collective unit for the purposes of taxation, conscription and some forms of servile dues. The periodic redivision of land among the households ensured that all had the means of paying their share of the head taxes, which were levied on the commune collectively. That is, the relative solidarity of the Russian repartitional commune is itself a result of a distinct history of relations with overlords. This claim is perfectly compatible with the fact that such solidarity, once in place, can serve other purposes, including resistance.

71 Fitzgerald, *Stalin's Peasants*, p. 106 (emphasis added).

72 I am immensely grateful to my colleague Teodor Shanin and his research teams, who are conducting comparative work on more than 20 collective farms, for making available to me the maps and photographs for this chapter. Particular thanks to Galya Yastrebinskaya and Olga Subbotina for the photograph of the older village of Utkino, founded in 1912 and located 20 miles from the city of Vologda.

73 Notice that the old-style houses that were not moved (legend reference 12) are themselves laid out on roughly equal plots along the main road. I do not know whether there were administrative reasons behind these forms in the 18th century, when the village was founded, or whether the original pioneers themselves laid out the grid. How the older houses that have been relocated were originally disposed is also a mystery.

74 The same logic, of course, applied to industry, in which large units are favoured over small factories or artisanal production. As Jeffrey Sachs has observed: 'Central planners had no desire to coordinate the activities of hundreds or thousands of small firms in a sector if one large firm could do the job. A standard strategy, therefore, was to create one giant firm wherever possible' (*Poland's Jump into the Market Economy* [Cambridge: Cambridge University Press, 1993]). In the context of the Soviet economy, the largest industrial unit was the huge steel complex at Magnitogorsk. It is now a stunning example of an industrial and ecological ruin. See also Kotkin, *Magnetic Mountain*.

75 For a more extensive treatment of the ecological effects of Soviet agriculture, see Murray Feshbach, *Ecological Disaster: Cleaning Up the Hidden Legacy of the Soviet Regime* (New York: 1995), and Ze'ev Wolfson (Boris Komarov), *The Geography of Survival: Ecology in the Post-Soviet Era* (New York: M. E. Sharpe, 1994).

76 I worked for six weeks in 1990 on a cooperative (ex-collective) farm in East Germany, on the Mecklenburg Plain, not too far from Neubrandenburg. The local officials were exceptionally proud of their world-class yields per hectare in rye and potatoes with high starch content grown for industrial uses. It was clear, however, that as an economic matter, the market cost of the inputs (labour, machinery and fertilizer) needed to produce these yields made this enterprise an inefficient producer by any cost-accounting standard.

77 There is no doubt that a number of bureaucratic 'pathologies' amplified the disaster of Soviet collectivization. They include the tendency of administrators to concentrate on specified, quantifiable results (e.g., grain yields, tons of potatoes, tons of pig iron) rather than on quality and the fact

that long chains of specialization and command shielded many officials from the larger consequences of their behaviour. Also, the difficulty of making officials accountable to their clientele, as opposed to their superiors, meant that the pathology of group 'commandism', on one hand, or individual corruption and self-serving, on the other, were rampant. High-modernist schemes in revolutionary, authoritarian settings like that of the Soviet Union are thus likely to go off the rails more easily and remain off the rails far longer than in a parliamentary setting.

78 The rush towards collectivization was momentarily halted by Stalin's famous 'Dizzy with Success' speech of March 1930, which prompted many to leave the collectives; however, it was not long before the pace of collectivization resumed. In order to have enough capital for rapid industrialization, 4.8 million tons of grain were exported in 1930 and 5.2 million tons in 1931, helping to set the stage for the famine of the years immediately following. See Lewin, *The Making of the Soviet System*, p. 156.

79 Compare this with Bakunin's forecast of what state socialism would amount to: 'They will concentrate all of the powers of government in strong hands, because the very fact that the people are ignorant necessitates strong, solicitous care by the government. They will create a single state bank, concentrating in its hands all the commercial, industrial, agricultural and even scientific producers, and they will divide the masses of people into two armies – industrial and agricultural armies under the direct command of the State engineers who will constitute the new privileged scientific-political class' (quoted in W. D. Maximoff, *The Political Philosophy of Bakunin: Scientific Anarchism* [New York: Free Press, 1953], p. 289).

80 The term 'elective affinity' comes from Max Weber's analysis of the relation between capitalist norms and institutions on one hand and Protestantism on the other. His argument is not one of direct causation but of 'fit' and symbiosis.

81 See books 4 and 5 in vol. 2 of Gabriel Ardant, *Théorie sociologique de l'impôt* (Paris: CEVPEN, 1965).

82 Quoted in Michel Crozier, *The Bureaucratic Phenomenon* (Chicago: University of Chicago Press, 1964), p. 239. As Abram de Swaan has noted, 'The nineteenth-century school regime does reveal some unmistakable similarities with the factory regime of that time: standardization, formalization and the imposition of punctuality and discipline were paramount in both' (*In Care of the State*, p. 61).

83 Scott J C. 1998. Chapter 8 in *Seeing Like a State.* New Haven: Yale University Press.

84 For a detailed account of the relationship between the private plot and the collective just prior to 1989, see Timofeev, *Soviet Peasants, or The Peasants' Art of Starving*.

15

Alternatives to Slash-and-Burn: Challenge and Approaches of an International Consortium

Pedro A. Sanchez, Cheryl A. Palm, Stephen A. Vosti, Thomas P. Tomich and Joyce Kasyoki

The Challenge

The world has lost about half of its forests to agriculture and other uses, and 78 per cent of what remains is heavily altered, bearing little resemblance to the original forests (Bryant et al, 1997). About 72 per cent of the original 1450 million ha of tropical forests have been converted to other uses (Myers, 1991; FAO, 1997). Deforestation rates for the humid tropics were estimated to be 6.9 million ha/yr at the end of the 1970s (Lanly, 1982) and doubled to 14.8 million ha/yr by 1991 (Myers, 1993). More recent studies indicate that deforestation rates decreased by about 10 per cent in the 1990s (Durst, 2000). These values are fraught with methodological problems. Achard et al (2002) asserted that previous methods overestimated tropical deforestation rates by as much as 25 per cent. Brazil, the country with the largest area of tropical forests, reports that deforestation rates in the Brazilian Amazon increased by as much as 40 per cent from 2001 to 2002 (INPE, 2003). Despite these limitations, it is obvious that tropical deforestation and subsequent ecosystem degradation continue at alarming rates. They remain a major worldwide concern because of the high levels of plant and animal biodiversity these forests contain, the large carbon (C) stocks stored in them, and the many other ecosystem services tropical forests provide (Myers, 1993; Laurance et al, 1997).

Small-scale farmers often are viewed as the primary agents of deforestation (Hauck, 1974), accounting for as much as 96 per cent of forest losses (Amelung and Diehl, 1992). Myers (1994) reported that the aggregate actions of small-scale farmers resulted in greater deforestation than the activities of large-scale operations

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and accounted for about 70 per cent of the deforestation in Africa, 50 per cent in Asia, and 30 per cent in Latin America. Although the predominant role played by small-scale farmers has come into question (Geist and Lambin, 2002), they are often part of the deforestation process.

Small-scale farmers practising slash-and-burn agriculture clear forests to produce food and make a living for their families. They often have few options other than to continue clearing tropical forests because of the benefits and profits derived from deforestation. In many cases, these farmers are marginalized from society and government support programmes, and often they are migrants escaping from poverty and inequities elsewhere in the country. Any efforts to arrest deforestation must consider this group; in the absence of alternatives they will continue to clear forest to meet their needs for food and income.

Early approaches to conserve tropical forests were done at the exclusion of small-scale farmers that depend on the forest for their livelihoods (FAO Staff, 1957). These 'fence off the forest' approaches often increased conflicts between conservation and development efforts and ignored the causes of deforestation. The importance of agricultural development for reducing the poverty of the small-scale farmers and the economic development of developing countries is increasingly recognized. Therefore the development and promotion of agricultural systems that reduce poverty must be integrated with strategies to conserve tropical forests and the biodiversity and carbon they house (McNeely and Scherr, 2003). The challenges are to identify alternative systems that meet farmers' needs and that can reduce pressure to clear more forest or minimize the impacts on biodiversity and other global environmental resources. The Alternatives to Slash and Burn (ASB) consortium was created to address this challenge.

This chapter introduces the ASB Programme, an international consortium of researchers and extension groups that was established specifically to investigate the causes and consequences of deforestation by small-scale farmers and to identify land-use systems that enhance both local livelihoods and the environment and the policies and other changes needed to support them. It begins with a description and distinction of shifting cultivation and slash-and-burn practices and continues with a summary of land-use intensification pathways in the tropics. This is followed by the objectives, benchmark site locations, broad methods and activities of the ASB consortium.

Land Use at the Tropical Forest Margins

Almost all tropical forests are cleared by similar methods that start with slashing the forest with chainsaws, axes and machetes and burning the felled vegetation after it has dried. In this sense, slash-and-burn is simply a land-clearing technique. The subsequent land-use pathway that follows land clearing differs depending on the different groups of people involved – indigenous forest dwellers, small-scale farmers and large-scale private operators – and the intended use of the land, including the various types of shifting cultivation, agroforestry, logging, cattle ranching and commercial tree plantations. There is much confusion in the literature regarding the use of the terms *shifting cultivation* and *slash-and-burn agriculture*; the following sections distinguish between the different land-use pathways that follow the clearing of tropical forests.

Shifting cultivation or slash-and-burn agriculture?

Shifting cultivation is probably the oldest farming system (Nye and Greenland, 1960) and is remarkably similar throughout the humid tropics. Farmers slash and burn a hectare or so of primary or tall secondary forest, grow food crops in polyculture for 1–3 years, and abandon the land to secondary forest fallow regrowth for 20–40 years, then repeat the cycle. This traditional shifting cultivation with short cropping periods and long secondary forest fallow periods is now rare, practised primarily by indigenous communities disconnected from the national economy. It is socially and environmentally sustainable (Thrupp et al, 1997), albeit at low levels of agricultural productivity and human population densities of less than 30 people per square kilometre (Boserup, 1965). Shifting cultivation is known by a variety of terms, referring mostly to cleared fields: *swidden* (Old English), *rai* (Sweden), *milpa*, *conuco*, *roza* (Latin America), *shamba*, *chitemene* (Africa), *jhum* (India), *kaingin* (Philippines), *ladang* (Indonesia and Malaysia) and many others. Fallows are commonly called bush fallow and *jachere* in Africa; *barbecho*, *capoeira* and *purma* in Latin America; and *belukar* and other terms in Indonesia. The concept of fallows in the tropics differs from that used in the temperate zone, where the term *fallow* normally means leaving the soil bare (Sanchez, 1999). The vegetative fallow phase restores carbon and nutrient stocks in the biomass, improves soil physical properties and suppresses weeds (Nye and Greenland, 1960; Sanchez, 1976; Szott and Palm, 1986).

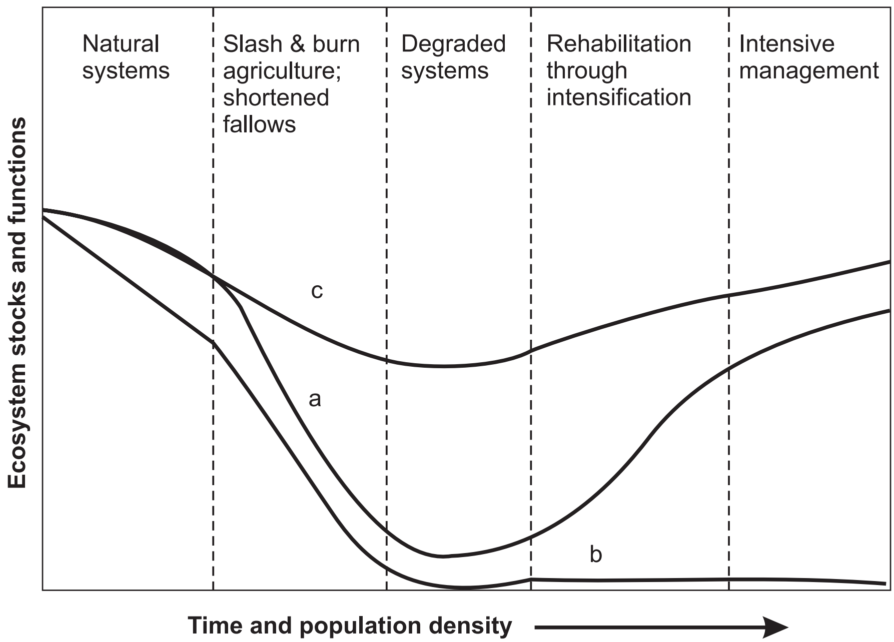
When human population pressures exceed a critical density that varies with agroecological zones and inherent soil fertility, traditional shifting cultivation is replaced by a variety of other agricultural practices that still involve clearing by slash-and-burn methods. We suggest that the loosely used terminology be specified as follows: *shifting cultivation* refers to the traditional long-fallow rotational system, and *slash-and-burn agriculture* refers to other farming systems characterized by slash-and-burn clearing, short-term fallows or no fallows at all. These systems include the shortened fallow–food crop systems and the establishment of tree-based systems such as complex agroforests, simple agroforests or monoculture tree crop plantations such as oil palm (*Elaeis guineensis* Jacquin), coffee (*Coffea* spp.), rubber (*Hevea brasiliensis* [Willd. ex A. Juss.] Muell.-Arg.) or pulp and timber species. Slash-and-burn is also the means of establishing pastures that are found throughout the humid forest zone of Latin America. These slash-and-burn systems differ from shifting agriculture in that the crops are interplanted with pastures or tree seedlings, or in some cases the cropping period is omitted. Many of the systems are still rotational to some degree, with occasional slash-and-burn clearing when the productivity of the system declines.

Land-use intensification pathways

The pathway of agricultural intensification depends to some extent on the biophysical environment but is modified by the demographic composition and pressures, production technologies, and natural resource management practices, infrastructure, institutions and policy environment present at the time. The usual pathway begins with the reduction of the fallow period to less than 10 years and more commonly less than 5 years. These short fallows are incapable of accumulating sufficient nutrient stocks in the biomass and suppressing weeds by shading. Unlike shifting cultivation, where soil erosion is seldom a problem, slash-and-burn systems have less vegetative cover and often exposed, compacted soils that increase water run-off and soil erosion rates (Lal et al, 1986). This change in vegetation and soil structure may lead to changes in the hydrologic cycle, with negative consequences downstream (Bruijnzeel, 1990; Tinker et al, 1996). The combined effects of shortened fallows result in systems with declining productivity, depending more and more on less and less fallow biomass. In some cases, the systems reach a point at which the trees are replaced by other, highly degraded systems such as *Imperata cylindrica* (L.) Beauv grasslands in South-East Asia and West Africa (Garrity, 1997) and degraded pastures in Latin America (Serrão and Homma, 1993). This pathway of land-use intensification, land degradation and the resulting losses of carbon stocks, nutrients and biodiversity is depicted in the left-hand, declining curve in Figure 15.1, line *a*. It is important to remember that those and other ecosystem services have been traded for private benefits, including food, feed, fibre and cash.

With further increases in population density come increased access to markets and decreased access to forest products. A point may be reached when land degradation begins to be reversed with changes in land tenure institutions that facilitate investments in improved land management. This process was recognized by Boserup (1965) and is sometimes called induced institutional innovation (Hayami and Ruttan, 1985). Land rehabilitation usually is accomplished by replenishing lost plant nutrients; using improved crop germplasm, agronomic practices and soil conservation methods; introducing livestock; and planting more trees.

Farmers will invest in improved land management and care for the environment when they have reasonably secure land or tree tenure and if it is profitable compared with other investment options within the context of household constraints and individual time preferences and attitudes toward risk. Examples of soil and land rehabilitation with increasing population pressure are well documented as ‘more people, less erosion’ (Tiffen et al, 1994) and ‘more people, more trees’ (Sanchez et al, 1998). They are accompanied by increasing productivity and profitability. Ecosystem stocks of carbon and nutrients increase and other ecosystems services also return, the level of which depends on the previous state of degradation and on the type of land-use system that is established. Livelihoods may continue to improve as more and more valuable economic products are obtained from the system. The trade-offs between the environmental services and profitability are



Note: Line *a* represents the usual pattern of land degradation and eventual rehabilitation when the proper policies and institutions are in place, line *b* represents the continued state of degradation that can occur in the absence of appropriate policies and institutions, and line *c* represents the desired course where there is little degradation of the resource base yet improved livelihoods are achieved.

Source: Sanchez et al, 1998

Figure 15.1 *Land-use intensification pathways and changes in stocks of natural capital such as carbon and nutrient stocks, biodiversity and other ecosystem services, with time and increasing population density in the tropics*

lower than those in the degraded state. This is the right-hand side of Figure 15.1, line *a*. In some cases, the policy environment does not provide incentives to rehabilitate these degrading lands (line *b* in Figure 15.1), and the challenge is to find policy tools that will provide those incentives.

Alternative land-use intensification pathways that do not first involve severe land degradation (line *c* in Figure 15.1) do exist in the form of the complex agroforests that have been developed by indigenous communities (Padoch and de Jong, 1987; Michon and de Foresta, 1996; Duguma et al, 2001). The challenge is, first, to identify and understand barriers to adoption of other systems by smallholders when such systems are superior alternatives in terms of their environmental impacts and sustainability as well as their profitability, food security, riskiness and other measures of acceptability to smallholders. When such superior win–win alternatives exist, the next challenge is to identify means to reduce barriers to adoption by smallholders before land degradation occurs to such an extent that ecosystems services are lost. More often, however, there is no single 'best bet', but instead there is a range of trade-offs across land-use alternatives regarding environmental and agricultural development objectives.

Who are the small-scale slash-and-burn farmers?

The number of people who depend on shifting cultivation for their livelihoods has for decades been estimated at about 250–300 million (Hauck, 1974; Myers, 1994). Recent georeferenced population and farming system data suggest that the numbers are an order of magnitude lower. Dixon et al (2001) report that 37 million people, or 2 per cent of the agricultural population of the tropics, practise some form of shifting cultivation in about 1 billion ha or 22 per cent of the tropical land area. This is the area of influence, but only a small fraction of that is under actual cropping or fallows. These numbers do not include people practising more intense systems in the humid tropics that were originally established by slash-and-burn practices. The number of people involved in these other crop-based, tree-based or pasture-based slash-and-burn systems is several times that of shifting cultivators (Dixon et al, 2001).

Deforestation by slash-and-burn farmers is a response to underlying root causes. Population growth is naturally viewed as a main driver of deforestation, and economic growth often is viewed in the same vein. But no direct relationship between deforestation and population growth or economic growth has been found. Myers (1991) noted that whereas the population of forested tropical countries increased by 15–35 per cent in the 1980s, deforestation expanded by 90 per cent during the same period. The recent analysis by Geist and Lambin (2002) shows that in-migration to the forest margins is a much larger factor in deforestation than high internal population growth. Brown and Pearce (1994) obtained inconclusive results when attempting to relate gross domestic product (GDP) growth rates, foreign debt and population growth with deforestation in tropical countries. Rudel and Roper (1997) found that in tropical countries with large forested areas, deforestation increases with increasing GDP, whereas in countries with mainly forest fragments, increasing GDP decreases deforestation.

Whereas traditional, indigenous people practise shifting cultivation, many (in some cases most) of the people practising slash-and-burn agriculture are migrants from other parts of their country who seek a better life at the forest margins. In some countries, large numbers of migrants to the forest margins come as part of government-sponsored colonization programmes aimed at transmigrating poor people from densely populated areas to the forest frontier, particularly in Brazil and Indonesia (Hecht and Cockburn, 1989; Kartasubrata, 1991). Others are spontaneous migrants who, acting independently with little or no government support, follow the opening of roads and logging trails. Planned and spontaneous migrations of poor people from crowded regions such as Java, the Andes and north-eastern and southern Brazil have undeniably contributed to deforestation. Opening of roads into primary forests such as the Belém-Brasília, Transamazônica and São Paulo–Rio Branco in Brazil, the Carretera Marginal de la Selva and the Federico Basadre in Peru, and the Trans-Sumatra and Trans-Gabon highways have provided access to forests to both small-scale farmers and commercial interests.

Many of these migrants are unfamiliar with the humid tropics, are largely unaware of the knowledge-intensive practices of indigenous shifting cultivators, and attempt to establish cropping systems that work where they came from (Moran, 1981). People in these situations usually lack alternative employment opportunities; have limited access to markets, credit and information; and often are politically marginalized. These people are a major focus of the ASB consortium.

The ASB Consortium

The ASB consortium is an international group of researchers, extension workers and non-government organizations (NGOs) established in February 1992 to investigate the causes and consequences of deforestation by small-scale farmers and to identify land-use systems that enhance local livelihoods and the environment and the policies and other changes needed to support them. The ASB focuses on areas with high rates of deforestation where rapid increases in population density caused primarily by inmigration result in conversion of natural forests and where the environment–livelihood trade-offs are large. The ASB does not focus on shifting cultivation, but in some locations where it did occur, it was included in the comparative analysis. Similarly, larger-scale slash-and-burn operations also were included in some of the comparisons.

State of knowledge

A literature review undertaken in 1992 showed much process-based understanding of agricultural practices, empirical understanding of global environmental processes and social processes, some policy research, and almost no multidisciplinary research (Sanchez and Bandy, 1992; Bandy et al, 1993; Sanchez and Hailu, 1996). The biophysical processes of shifting cultivation and slash-and-burn systems have been well understood through decades of long-term, place-based research (Nye and Greenland, 1960; Jurion and Henry, 1969; Sanchez, 1976; Juo and Lal, 1977; Seubert et al, 1977; Serrão et al, 1979; Macintosh et al, 1981; Toky and Ramakrishnan, 1981; Sanchez et al, 1983, 1987; Ramakrishnan, 1984, 1987; Smyth and Bastos, 1984; Von Uexkull, 1984; Alegre and Cassel, 1986, 1996; Sanchez and Benites, 1987; Wade et al, 1988; Kang et al, 1990; Cerri et al, 1991; Palm and Sanchez, 1991; Smyth and Cassel, 1995; Juo and Manu, 1996; Palm et al, 1996).

The environmental consequences of slash-and-burn and tropical deforestation on greenhouse gas emissions have been modelled or estimated with limited data on the rates of deforestation, the carbon stored in the forests and subsequent land-use systems (Houghton et al, 2000). Much data have been gathered on the effects of tropical deforestation on above-ground biodiversity (Whitmore and Sayer, 1992; Heywood, 1995) and watershed hydrology (Bruijnzeel, 1990; Tinker et al, 1996), but with limited specificity to slash-and-burn agriculture. There were only a few studies on below-ground biodiversity (Lavelle and Pashanasi, 1989).

The anthropological aspects of shifting cultivation have been described extensively (Conklin, 1954, 1963; Cowgill, 1962; Padoch and de Jong, 1987; Thrupp et al, 1997), with more recent studies focusing on migrants practising slash-and-burn agriculture (Moran, 1981; Colfer et al, 1988; Rhoades and Bidegaray, 1987; Fujisaka et al, 1991). There have been several studies about the economics and policies of deforestation and slash-and-burn practices, focused primarily on Brazil (Mahar, 1988; Binswanger, 1991; Brown and Pearce, 1994; Mahar and Schneider, 1994).

What this incomplete literature review showed was an almost total absence of multidisciplinary work. Social and biophysical scientists have seldom worked together on slash-and-burn issues. There was no tradition of joint research and collaboration between economic groups and the environmental community dealing with this issue (Repetto and Gillis, 1988), or between the agricultural, economic and environmental communities. The ASB consortium was established to link the diverse research disciplines and the development community to address jointly the problems of deforestation, unsustainable land use and rural poverty at the humid forest margins.

Inception

A United Nations Development Programme (UNDP)-sponsored workshop was held in Porto Velho, Rondônia, Brazil, 16–21 February 1992, attended by 26 environmental policy makers and research leaders from eight tropical countries, five NGOs, six international agricultural research centres, three regional research organizations and six donor agencies (ASB, 1992). Participants concluded that a global effort was needed because the problem and impacts were global and that cross-site comparisons of causes and solutions could provide insights not possible from isolated studies. The participants created the ASB consortium, set the broad basis for collaboration, selected three initial benchmark sites, and formed a governing body to guide the intricate linkages and processes.

Two key recommendations of the Rio Earth Summit that was held later in 1992 provided international legitimacy to the ASB consortium. They appear in chapter 11, 'Combating Deforestation', of Agenda 21, as follows (Keating, 1993):

> Limit and aim to halt destructive shifting cultivation by addressing the underlying social and ecological causes.
>
> Reduce damage to forests by promoting sustainable management of areas adjacent to the forests.

Goal, hypothesis and objectives

The overall goals of the ASB consortium are to help reduce the rate of deforestation caused by slash-and-burn agriculture, rehabilitate degraded lands created by slash-and-burn, and improve the well-being of slash-and-burn farmers by providing economically and ecologically viable alternative land-use practices.

The underlying hypothesis at the inception of ASB was that intensification of agricultural systems on already cleared lands and rehabilitation of degraded lands at the humid forest margins would reduce deforestation. Although this hypothesis has since been shown to be too simplistic because the underlying behavioural assumptions were wrong (Angelsen and Kaimowitz, 2001), it provided a framework around which the programme focused its initial research objectives and activities:

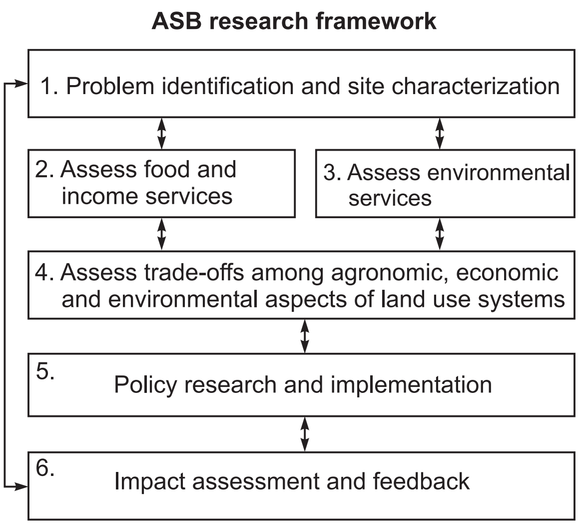
- *Site characterization*. Assess the principal socioeconomic and biophysical processes leading to deforestation, including government policy and decision-making patterns of farmers practising slash-and-burn.
- *Environmental and agronomic sustainability studies*. Quantify the contribution of slash-and-burn agriculture and alternative land-use practices to global, regional and local environmental changes such as climate change, biodiversity loss and land degradation.
- *Socioeconomic studies and trade-off analysis*. Integrated assessment of land-use alternatives to identify appropriate technologies and develop improved production systems that are economically feasible, socially acceptable and environmentally sound alternatives to current slash-and-burn systems or to understand trade-offs between land-use alternatives.
- *Policy research and implementation*. Identify policy options and institutional reforms that can facilitate the adoption of the improved systems and the balancing of trade-offs to attain a more desirable mix of outcomes and discourage further deforestation.

Succinctly stated, are there alternative land-use systems to slash-and-burn that reduce deforestation, poverty and global environmental changes such as greenhouse gas emissions and biodiversity loss? What are the type and magnitude of the environmental and livelihood trade-offs for these different systems? And, based on that trade-off analysis, how can the systems be influenced to attain better outcomes for a range of stakeholders, including farmers?

The slash-and-burn topic is complex, involving multiple agents, land-use objectives and driving forces (Tomich et al, 1998b). In addition, slash-and-burn is carried out in a diverse array of biophysical, socioeconomic and policy environments. To address the objectives of the ASB consortium requires an understanding of the influence of these multiple factors and environments on the economic viability, sustainability and environmental impacts of the alternatives. From the outset ASB determined four key features to assist in this complex task: a cross-disciplinary approach combining biophysical and behavioural sciences, the participation of diverse kinds of institutions, work based at benchmark sites, and common methods to be used at all sites. The benchmark sites and standard protocols are introduced in this chapter.

Cross-disciplinary research and development framework

The ASB developed a conceptual framework in which the land-use system adopted by farmers depends on farm households' objectives; their natural, human, social, technical and financial resources; and the biophysical, social, economic and political constraints to the use of these resources. The effects of these land-use systems for alleviating poverty, conserving resources and reducing deforestation were then assessed along with the impacts of current and alternative policies (Palm et al, 1995; ASB, 1996). An integrated natural resource management (INRM) research framework that was later developed by the international agricultural research centres (Figure 15.2; CIFOR, 2000; Izac and Sanchez, 2001) was based largely on the ASB experience. The various steps in the research process of problem identification, assessment of food and income services, assessment of ecosystem services, trade-off analysis, policy research and implementation, and impact analysis are discussed in the following sections.



Source: Modified from ASB, 1996; CIFOR, 2000; Izac and Sanchez, 2001)

Figure 15.2 *The research and development framework used by ASB*

Diverse institutions

In 2001 the ASB consortium was composed of seven national agricultural research systems, four other national agencies, seven international agricultural research centres, 20 universities and advanced research institutions, and five local and national NGOs. The ASB researchers have organized themselves in an evolving collection of multidisciplinary thematic working groups, including site characterization, biodiversity (above- and below-ground), climate change, agronomic sustainability, sustainable land-use mosaics, farmer concerns, policy and institutional issues, synthesis and linkages, and training and capacity building. A Global Steering Group provides governance to the consortium. It meets yearly and sets overall policy, funding strategy and reporting. A global coordinator with a small global team of two to three staff facilitates operations (Swift and Bandy, 1995).

Benchmark sites

A network of benchmark sites was identified to represent large, active areas of deforestation caused by slash-and-burn practices. The sites that were selected provide a range of biophysical and socioeconomic conditions under which slash-and-burn occurs and include a land-use intensity gradient from traditional shifting cultivation to intensive continuous cropping and degraded lands. Benchmark sites were also selected based on sufficient infrastructure to conduct the research and development activities. Each benchmark site covers a large area and has a national research station as its physical base, but the bulk of the work is done locally with researchers, NGOs, extension services, farmers and policy makers.

Latin America

Two areas were selected in the Amazon Basin; they represent areas that have experienced rapid deforestation as a result of government colonization programmes (western Amazon Brazilian benchmark site) and other areas of lower population density and poor infrastructure where population densities are increasing through spontaneous migration from the overcrowded urban and Andean areas (Peruvian benchmark site). The site in the western Brazilian Amazon encompasses two colonization projects, Pedro Peixoto, Acre and Theobroma, Rondônia, and areas along the BR-362 highway. Settlements are all under government sponsorship, with migrants assigned 50- to 100-ha plots, and currently undergoing rapid development. The site headquarters is the Empresa Brasileira de Pesquisa Agropecuária (Embrapa)–Acre research centre, near Rio Branco. The Peruvian benchmark area focuses on Pucallpa and Yurimaguas in the Ucayali and Loreto regions of the Selva Baja. The site is managed from the Center for Forestry Research (CENFOR) of the Instituto Nacional de Investigación Agraria (INIA), working in close cooperation with Consorcio para el Desarrollo Sostenible de Ucayali (CODESU), a group of NGOs, the Ucayali Regional Government, the Instituto de Investigación de la Amazonía Peruana (IIAP), and INIA's Yurimaguas Experiment Station.

A third area in Latin America represents the humid and subhumid forests of the Atlantic Coast of Central America and Mexico where encroaching urban areas and slash-and-burn has reduced the extent of the northernmost extension of tropical forests. The benchmark area in the Yucatan in south-east Mexico was managed by Instituto Nacional de Investigación Forestales, Agricolas y Pecuarias (INIFAP).

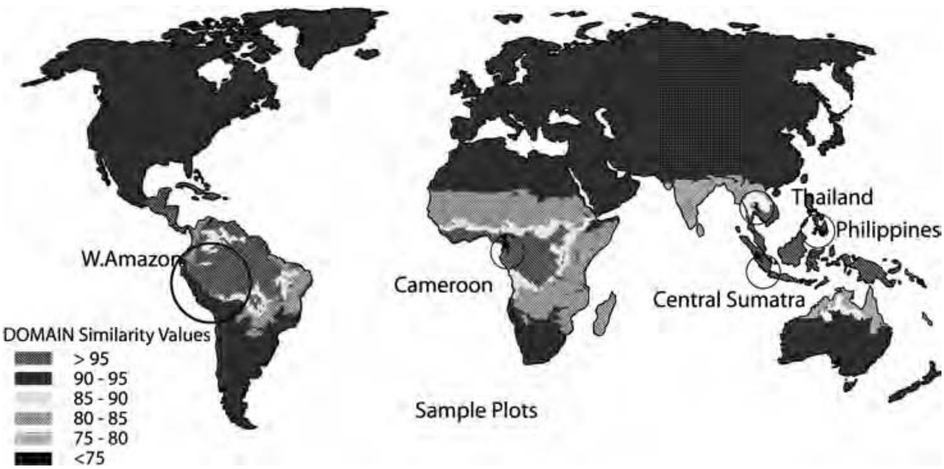
Africa

A site in Cameroon represents the equatorial Congo Basin rainforest of Congo–Kinshasa, Congo–Brazzaville, Equatorial Guinea, Gabon, Central African Republic, and Cameroon, where there is low but increasing population density and largely indigenous slash-and-burn agriculture. The site includes a north–south gradient, from rapid, spontaneous colonization around Yaoundé at the north, though an intermediate situation at M'Balmayo, to very low population density at Ebolowa in the southern end, close to the Gabon–Equatorial Guinea border. Site headquarters are at the Institut de Recherche Agricole pour le Développement (IRAD) at Nkolbisson, near Yaoundé, with strong support from the IITA Humid Forest Centre.

South-East Asia

Sites in South-East Asia represent three quite different forest ecosystems. The Sumatran benchmark area in Indonesia represents the equatorial rainforests of the Indonesian and Malaysian archipelago. Located in Jambi and Lampung provinces, it covers a broad gradient from primary forests in the Jambi area to degraded *Imperata* grasslands in Lampung Province, including both indigenous farmers and colonization projects as well as large-scale plantations and logging companies. The site is managed from the Central Research Institute for Food Crops (CRIFC) of the Agency for Agricultural Research and Development (AARD) in Bogor, Java. A benchmark area in the Philippines represents the monsoonal forests, where only forest remnants exist on steep mountain slopes and degraded grasslands dominate the landscape. The sites in Claveria and Lantapan in Northern Mindanao, Philippines, are operated by the Philippine Council for Agriculture, Forestry, and Natural Resources Research (PCARRD) together with a number of other organizations. A benchmark area in the Ma Chaem watershed near Chiang Mai, Thailand, represents the extensive area of subtropical hill forests of mainland mountain South-East Asia found in Thailand, Myanmar, Laos, Vietnam and southern China. The site was chosen to extend ASB research into higher-elevation areas with broad ranges of slope conditions where issues of land-use management often overlap with issues of watershed management. The benchmark site is managed by Thailand's Royal Forest Department in close collaboration with Chiang Mai University.

All benchmark sites fall within the tropical and subtropical moist broadleaf forest biome (WWF, 2001). To indicate how much the benchmark sites represent other areas in the tropics, regional similarity classes were developed from a set of key physical, environmental determinants of plant growth. The DOMAIN potential



Note: The DOMAIN similarity values are based on elevation, potential evapotranspiration, total annual precipitation, precipitation in the driest month, precipitation range, minimum average monthly temperature and maximum average monthly temperature.

Source: Gillison, 2000

Figure 15.3 *Map indicating the location and global environmental representativeness of the ASB sites in western Amazon, Indonesia, Thailand, Philippines and Cameroon*

mapping procedure developed by Carpenter et al (1993) was used to generate the map shown in Figure 15.3 of matching climate surface values for each of 108 sample locations in ASB's benchmark sites in Brazil, Indonesia and Cameroon. The various similarity classes indicate the degree to which the ASB sites can be extrapolated over a global surface using the same climate variables.

Initial ASB research was concentrated in the Brazil, Cameroon and Indonesian benchmark sites, and these three thus serve as the focus for this chapter, although much progress has also been made in Thailand and Peru.

Research Themes and Methods

The ASB integrates a range of geographic sites, spatial and temporal scales, disciplines, and partner institutions. To implement the various steps of the interdisciplinary INRM research framework at the various sites demanded a minimum, common research approach for making cross-site comparisons. Standardized methods were developed for identifying problems and characterizing sites (Figure 15.2, step 1), quantifying the environmental, agronomic and socioeconomic parameters of the different land-use alternatives (steps 2 and 3), assessing the economic and environmental trade-offs (step 4), and researching and implementing policies (step 5). The various methods are described in detail in this section.

Characterizing sites

The first phase of ASB research involved characterizing the benchmark sites. The purpose of the characterization was to describe the biophysical, socioeconomic and policy settings of the sites, define the extent and process of slash-and-burn agriculture in forming land-use patterns, investigate the driving forces for slash-and-burn, develop typologies of slash-and-burn land-use systems that exist across the ASB sites, establish a baseline of information for future impact assessments, and provide regional and global extrapolation domains for research results. The results were used to identify research priorities and develop research protocols for the subsequent steps.

Guidelines were developed for characterizing the rates of forest conversion; dominant land-use systems; and the biophysical, socioeconomic and policy environments in which they are found at the regional, benchmark, community and farm and household scales (Palm et al, 1995). Within each benchmark site there are numerous communities that represent a range of demographic conditions and land-use histories that result in different local land-use patterns. The characterization process also included detailed interviews to establish the problems, opportunities, constraints and resources at the community and farm or household scales, the responses to which were important for identifying factors that affect decision making and driving forces of land use and for establishing research agendas for finding sustainable alternatives to slash-and-burn. Remote sensing and geographic information system (GIS) techniques were used to assess rates of deforestation and land-use patterns at the sites.

Site characterization results for the first three benchmark sites are documented by Ávila (1994) for Brazil, Ambassa-Kiki and Tiki Manga (1997) for Cameroon, and Gintings et al (1995) and van Noordwijk et al (1995) for Indonesia. Information is also presented in benchmark site reports (Tomich et al, 1998a; Kotto-Same et al, 2000; Lewis et al, 2002). A comparison of some of the key biophysical and socioeconomic conditions shows the broad range encompassed by benchmark sites (Table 15.1). Comparable activities and approaches for Mexico and the Philippines are presented in Haggar et al (2001) and Mercado et al (2001), respectively.

Meta-land-use systems

A set of meta–land-use systems was identified from the site characterization process that aggregates the broad range of specific land-use systems found in the diverse benchmark sites (ASB, 1996). Such systems were initially identified as 'best-bet' and 'worst-bet' alternative systems for specific benchmark sites (Tomich et al, 1998b). Meta–land-use systems include forests, complex agroforests, simple agroforests, crop–fallow rotations, continuous food crops, and pastures and grasslands (Table 15.2). This array of land uses covers a gradient often used by biophysical scientists to describe varying levels of disturbance of forest for agriculture (Ruthenberg, 1980; NRC, 1993). General descriptions of these meta–land-use systems and some specific examples are given here.

Table 15.1 *Selected site characterization parameters for the ASB benchmark areas*

Characterization parameter	*Western Amazon, Brazil*	*Southern Cameroon*	*Sumatran Lowlands, Indonesia*	*Selva Baja of Peru*	*Ma Chaem, North Thailand*
Rainfall (mm/yr)	1700–2400	1400–1900	2500–3000	1500–2200	1200–1500
Latitude	7–12°S	2–4°N	0–6°S	6–12°S	20°N
Months dry season (<100mm)	June–September	July–August; October–February	June–August	June–August	November–April
Dominant original vegetation	Tropical moist forest; semideciduous forest	Tropical moist forest; semideciduous forest	Tropical moist forest	Tropical moist forest	Tropical semideciduous montane forest
Predominant soils (US Soil Taxonomy)	Paleudults, hapludox	Kandiudults	Hapludox, kandiudox, kandiudults, dystrudepts	Paleudults, paleaqualfs	Haplustults, dystrustepts
Population density (people/km^2)	3–5	4–200	2–175	1–9	20
Farm size (ha/household)	15–250[a]	5–30	2–10	2–50	2.4–16
Agricultural wage (US$/d)[b]	6.25	1.21	1.67	2.5	1.45, 1.75[c]

Notes: [a] Indicates small-scale farms as initially defined for Brazil.
[b] Wage rates are from 1996–1997.
[c] For women and men, respectively.

Source: Modified from Tomich et al (1998b)

Table 15.2 *Meta–land-use systems and candidate best-bet alternative systems (with some worst bets) at each ASB benchmark site*

Meta–land-use system	*Brazil*	*Cameroon*	*Indonesia*	*Peru*	*Thailand*
Forests	Natural forests Logged forests Extractive reserves Community-managed forests	Natural forests Logged forests Community-managed forests	Natural forests Logged forests Community-managed forests	Natural forests Logged forests Extractive reserves	Natural forests Logged forests Community-managed forests
Complex agroforests	None	Cocoa agroforests (jungle cocoa)	Rubber agroforests (jungle rubber)	Bora system	Tea agroforests (jungle tea)
Simple agroforests and intensive tree crops	Multistrata agroforests (cupuaçú + pupunha + castanha) Coffee + rubber Coffee + fast-growing timber	Oil palm plantations	Oil palm plantations Rubber monoculture plantations Pulpwood plantations	Peach palm Bolaina Capirona	Fruit orchards
Food crop–fallow systems	Coffee monoculture Annual food crop, 3-yr fallow Annual food crop, 2-yr legume fallow	Melon and mixed food crop, 15-yr fallow Mixed food crop, 4-yr bush fallow Mixed food crop, 4-yr *Chromolaena* fallow	Upland rice, 10-yr bush fallow Mixed food crops, 5-yr bush fallow Cassava, 2-yr *Imperata* fallow	Upland rice, cassava, short fallows	Upland rice, barley, ginger, short fallows
Continuous food crops	None	None	Cassava		Cabbages
Pastures and grasslands	Degraded pastures Improved pastures	None	*Imperata* grasslands	Degraded pastures Improved pastures	*Imperata* grasslands

Forests

Undisturbed or so-called primary forests are rare in and around the benchmark sites. Disturbed forests, with some degree of logging, are dominant, with the intensity of logging low in Cameroon, where a few trees are harvested per hectare, intermediate in Brazil and Peru, and high in Indonesia and Thailand. Extractive reserves, where non-timber forest products are harvested, are perhaps best known in the Amazon, where Brazil nuts or castanha (*Bertholletia excelsa* Humb. & Bonpl.) and rubber are harvested from naturally occurring trees, but at all sites some amount of nontimber forest products is harvested from forests of the different categories. The concept of sustainably managed community-based forests is being developed at the Brazil benchmark site by Embrapa. Community-protected secondary forests are found in the Thailand site and in Sumatra, Indonesia.

Complex agroforests

Complex agroforests contain a wide variety of economic plant species and usually have a rotation time greater than 20 years. The complex agroforests of Indonesia are indigenous systems established over generations by local peoples living at the margins of tropical rainforests in Sumatra, Borneo and other islands (Torquebiau, 1984; Foresta and Michon, 1994). Primary or old secondary forests are slashed and burned, food crops, citrus and robusta coffee (*Coffea canephora* Pierre ex Froehner) are planted along with several trees species, and natural regeneration of forest species is allowed. The trees eventually shade out the crops, occupy different strata, and produce high-value products such as fruits, resins, medicines and commercially valuable timber. The main economic tree species include damar (*Shorea javanica* Koord. & Valeton), durian (*Durio zibethinus* Murray), duku (*Lansium domesticum* Corr.) and rubber. In the case of rubber, production declines after 20 or 30 years, and the slash-and-burn cycle typically begins again; some of the other tree species, notably damar, can have much longer cycles. Alternatively, agroforests can be managed with gap replanting that eliminates the need for subsequent slash-and-burn cycles. In either case, such agroforests, composed of hundreds of small plots managed by individual families, occupy large contiguous areas in Sumatra and can be mistaken for forests to the untrained eye. Biophysical scientists have documented the high productivity and ecosystem services provided by these agroforests (Michon and de Foresta, 1996; Michon, 1997). Plant diversity in the mature complex agroforests is on the order of 300 species/ha, which approximates that of adjacent undisturbed forests (420 plant species/ha). The richness of bird species in mature agroforests is approximately 50 per cent that of the original rainforest, and almost all mammal species are present in the agroforest (Foresta and Michon, 1994). The villagers in Krui, Lampung Province, who make a living from these complex agroforests, have an obviously higher standard of living than those neighbours who grow only food crops (Bouamrane, 1996).

Complex agroforests based on cacao (*Theobroma cacao* [Linn.]) as the major cash crop have been developed in humid forest margins of West Africa over the past century (Duguma et al, 2001). Jungle tea (*Camellia sinensis* [L.] Kuntze) complex agroforests occur in North Thailand, where the naturally occurring tea trees are left when the forest is cleared and fruit trees are interplanted. Jungle rubber is a complex agroforest occupying 3 million ha where most of the rubber is produced in Indonesia. Indigenous Bora communities of the Peruvian Amazon establish complex agroforests by interplanting trees in upland rice and cassava crops (Padoch and de Jong, 1987). Economic trees include peach palm (*Bactris gasipaes* Kunth) for fruits and heart of palm, *Inga* spp. for fruits and firewood, arazá (*Eugenia stipitata* McVaugh) for fruit, and timber trees such as mahogany (*Swietenia macrophylla* King) and tornillo (*Cedrelinga cataeniformis* Ducke).

Simple agroforestry systems and intensive tree-crop systems

Simple agroforestry systems usually contain fewer than five economic plant species, whereas tree-crop plantations include only one. Both systems may include a leguminous crop cover. These systems are common in many parts of the humid tropics, particularly where infrastructure is well developed. Nevertheless, most of these start with slash-and-burn, in some cases followed by food crops interplanted with tree seedlings. Intensive tree-crop systems include the classic monoculture plantations such as oil palm and rubber, timber plantations such as pine (*Pinus* spp.), *Eucalyptus* spp., and cypress (*Cupressus* spp.), and fast-growing pulpwood plantations such as *Acacia mangium* and albizia (*Paraserianthes falcataria* [L.] I. Nielsen). These systems can be vast and run by corporations or run by individual smallholder farmers.

Simple agroforestry systems have less plant diversity than complex agroforests, higher levels of management are needed, and the regeneration of forest species is restricted. Included in this category are shade coffee, cacao and coconut plantations found throughout the humid tropics and the peach palm-based systems in Latin America. A slightly more diverse system based on peach palm, Brazil nut (*Bertholletia excelsa*), and cupuaçú (*Theobroma grandiflorum* [Willd. ex Spreng.] Schum) has been developed at the western Brazilian Amazon site.

Food crop–fallow rotations

Traditional shifting cultivation with long-term fallows was only found in the southern reaches of the Cameroon benchmark site and is absent in or disappearing from the other sites. Fallows of 10 years or less are more common at the other sites and include either natural secondary forest fallows or managed fallows (Sanchez, 1999). In the northern parts of the Cameroon benchmark site, shortening of the fallow period has resulted in the invasion and dominance of the bush *Chromolaena odorata* (L.) R. M. King and H. Robinson, a member of the Asteraceae family.

Improved or managed fallows, where trees are planted into the fallow, are now being tried in some of the benchmark sites. The planted trees often are nitrogen-fixing legumes that restore soil fertility more rapidly and include *Inga edulis* Mart. in Brazil and Peru or *Calliandra calothyrsus* Meissner in Cameroon. Deliberately planted fallows of *Tithonia diversifolia* (Hemsl.) Gray, another Asteraceae, are commonly found in the uplands of South-East Asia, practised by indigenous communities

(Cairns and Garrity, 1999). Improved fallows using leguminous cover crops kept in the field for less than 2 years occur in Peru and include kudzu (*Pueraria phaseoloides* [Roxb.] *Benth*) (Sanchez and Benites, 1987), *Mucuna* spp., and *Centrosema macrocarpum* Benth. (Palm et al, 2002a).

Continuous food crop production

Continuous cropping is found in valley bottoms as irrigated paddy rice (*Oryza sativa* L.) in Indonesia, Peru and Thailand, but because it is so well established and is rarely associated with slash-and-burn and deforestation it was not included in the analysis by ASB (except in Thailand). In Cameroon and Thailand, intensive horticulture with high rates of use of mineral fertilizers and pesticides forms an important option near the large urban centres of Yaoundé and Chiang Mai. Cassava is grown continuously in the Lampung area of the Indonesian benchmark site, particularly on transmigration settlement sites, and often eventually degrades through invasion by *Imperata cylindrica* into landscape patches or large grasslands.

Pastures and grassland systems

Pastures for beef production dominate the deforested landscape in the Brazilian and Peruvian benchmark sites. These include traditional, extensive pasture systems that degrade within a decade or so, as well as more intensive grazing systems with improved grass species (*Brachiaria humidicola* [Rendle] Schweick; *B. brizantha* [Hochst.] Stapf) often mixed with pasture legumes such as *Pueraria phaseoloides*, *Desmodium ovalifolium* Wall, *Arachis pintoi Krap. & Greg.*, and others (Serrão et al, 1979; Serrão and Toledo, 1990). The pasture species are tolerant to aluminum toxicity and are normally planted into a preceding crop of upland rice or maize (*Zea mays* L.). In parts of Brazil, these pastures are rejuvenated by burning, ploughing and fertilizing a maize crop to which pastures are replanted.

Extensive areas of *Imperata cylindrica* grasslands occur throughout South-East Asia and parts of West Africa. This species is known as alang-alang in Indonesia and cogon in the Philippines. These grasslands are dominant in the Lampung area of the Indonesian benchmark site (Garrity, 1997). This coarse, unpalatable grass invades areas where the fallow cycle has been shortened and is basically a degraded system. It is difficult to eradicate and is maintained by frequent fires. Fortunately *Imperata cylindrica* grasslands do not occur in Latin America, where less invasive *Imperata* species exist and pose no major problems.

These meta–land-use categories were used to set up land-use intensity transects or chronosequences at several locations in each benchmark site where environmental, agronomic and socioeconomic factors were evaluated by standard protocols. Whenever and wherever possible the different measurements were all taken from the same plot, farm or location in the landscape. Natural forest was considered the point of departure for all land uses, and grasslands, short-fallow cultivation systems and pastures were included as the other endpoint, representing degraded conditions. The specific environmental, agronomic and socioeconomic measurements are described in the sections that follow.

Quantifying environmental, agronomic and socioeconomic parameters

Climate change

Tropical deforestation and land-use change contribute as much as 25 per cent of the annual flux of carbon dioxide (CO_2) to the atmosphere (IPCC, 2001), yet there is still much debate on this issue because of uncertainties in biomass estimates, rates of deforestation and land-use change sequences. Changes in carbon stocks and the associated sources or sinks of atmospheric CO_2 and fluxes of nitrous oxide (N_2O) and methane (CH_4), the three most important greenhouse gases, were measured in the different land-use systems at the Brazil, Cameroon, Indonesia and Peru benchmark sites. Whereas most previous studies have focused on measurements in the forest and grassland or continuous cropping systems – in other words, the extremes – the dataset from ASB included measurements from many of the tree-based systems that often dominate the landscape in the humid tropics (Wood et al, 2000).

Carbon stocks in the above- and below-ground vegetation and in the top 20cm of the soil were estimated by a combination of allometric equations (for converting tree diameters into biomass) and destructive harvest. The concept of the average amount of carbon stored in each of the land-use systems during the time course of the rotations, or time-averaged carbon, was used for comparing land-use systems with different rotation times. The standardized methods for sampling are presented in Woomer et al (2000) and Woomer and Palm (1998). Results are presented in Woomer et al (2000) and Palm et al (2002b).

Estimating N_2O and CH_4 fluxes entails intensive, long-term sampling. This was not possible at most of the ASB sites. To obtain some estimates for annual fluxes and seasonal patterns for the different land-use systems, N_2O and CH_4 fluxes were measured monthly over the course of 2 years in the Indonesia and Peruvian benchmark sites using static chamber techniques. The sampling protocol and results are detailed in Ishizuka et al (2002) and Palm et al (2002a).

Biodiversity

Tropical forests contain two-thirds of the estimated 250,000 world's terrestrial plant species, 90 per cent of world's insects, and many bird species (Osborne, 2000), making tropical deforestation a primary cause of global biodiversity loss (Heywood, 1995; Stork, 1997). The extent of biodiversity loss associated with different land-use systems has seldom been considered, although many traditional land management strategies have supported biodiversity maintenance (McNeely et al, 1995; McNeely and Scherr, 2003). Diversity of the above-ground vegetation and below-ground biota were measured in the range of land-use systems at the benchmark sites to address these issues.

Above-ground plant diversity was measured as the number of plant species occurring in transects in each land-use type but also according to plant functional types (PFTs) (Gillison and Carpenter, 1997). Assessing plant diversity in the tropics is time-consuming and difficult, necessitating expertise in tropical plant identification and classification. The functional analysis uses a combination of adaptive morphologic or functional features (leaf size class, leaf inclination class, leaf form and type) and enables rapid characterization by people with minimal training. It includes measures of site physical features, vegetation structure, species composition, and PFTs (Gillison, 2001, 2002). Results from the benchmark sites are found in Gillison (2000).

Assessing diversity of below-ground biota is even more complex than above-ground vegetation, partly because many of the species have never been identified but also because sampling strategies that capture the spatial heterogeneity of the different types of biota have not been developed. The ASB below-ground biodiversity group designed a prototype sampling strategy and focused on assessing the biodiversity of certain functional groups of soil biota including macrofauna (earthworms, ants and termites), nematodes, arbuscular mycorrhizal fungi and rhizobial microsymbionts. Methods and results are presented in Swift and Bignell (2001).

Agronomic sustainability

The majority of soils in the humid tropics are acid and have low native fertility (Sanchez, 1976). Crops planted after slash-and-burn benefit from the nutrients in the ash, but rapid nutrient depletion takes place with successive nutrient removal in crop harvests, nutrient leaching, run-off and erosion promoted by high rainfall, and rapid decomposition of soil organic matter after burning. Soil physical properties also degrade with exposure caused by removal of the protective vegetation, and weeds invade fields, both of which contribute to declining crop yields (Sanchez et al, 1987; Juo and Manu, 1996). The long vegetative fallow characteristic of traditional shifting cultivation restores soil physical properties, accumulates carbon and nutrients in the fallow biomass, and eradicates weed populations. But as fallows shorten, their ability to perform these functions diminishes. The sustainability of the different land-use systems depends on the ability to maintain these vital ecosystem functions. A set of measurements that could indicate the sustainability of the systems was developed and includes soil structure and biological activity, nutrient balances and replacement costs, and weeds, pests and diseases. These criteria were assessed for the different land-use systems and then, based on expert judgement, translated into scales indicating the relative degree of difficulty farmers would face in solving the problem.

Household economic and social concerns

Regardless of the global environmental benefits or agronomic sustainability of a land-use system, farmers cannot be expected to adopt it unless it contributes more to meeting household objectives, does not entail excessive risks, and is compatible with the social and cultural norms of the community. The promotion of systems with greater environmental benefits must specifically consider the profitability, labour needs, food security and equity issues associated with them, as well as the institutions needed.

Methods to assess these objectives, their social and institutional needs, and the ability of farm households and communities to meet these needs were developed by the ASB consortium (Tomich et al, 1998a; Vosti et al, 2000) and used to assess the alternative land uses within and across sites. Key parameters included profitability (measured in terms of economic returns to land and labour), labour and capital needs for establishing and maintaining land-use systems, the potential contribution of given land-use systems to meet household food security needs, and market and nonmarket institutional needs of specific land-use systems. Detailed results of these studies for Brazil, Cameroon and Indonesia are found in Vosti et al (2001), Gockowski et al (2001) and Tomich et al (2001).

Analysing trade-offs: The ASB matrix

Land use at the humid forest margins is perceived by three general sets of beneficiaries. The global community is interested in saving tropical forests, increasing carbon sequestration, reducing greenhouse gas emissions and preserving plant and animal biodiversity. Small-scale farmers are interested in household food security, property rights, the profitability of their farms and the institutions that support their goals. National policy makers occupy intermediate positions and can be the key actors. In 1996, ASB researchers developed a framework known as the ASB matrix to help evaluate the local, national and global impacts of the alternative land-use systems and guide their decisions (Table 15.3; Tomich et al, 1998b).

The evaluation criteria include the environmental, agronomic and socioeconomic impacts, previously described, for each of the land-use options. The matrix puts together the food and income functions with ecological functions (production, human welfare and environmental impacts) of each system, indicating the potential trade-offs between the perspectives and interests of different stakeholders. This framework is intended for use in selecting from among the land-use alternatives. The challenge is for the multiple stakeholders to weigh trade-offs between their varied objectives. The notion of best-bet alternatives was introduced to indicate the systems that provide the combination of environmental services, poverty level and economic growth that is most acceptable to society in the production (private) and environmental (global) functions. Some advantages and limitations of the matrix are discussed in Vosti et al (2000) and Tomich et al (1998b).

The analysis of the resulting trade-off matrix must be done with full participation of the various stakeholders and is crucial for achieving a common understanding of the different viewpoints, vested interests and potential conflicts associated with the different choices. An example of the types of trade-offs is that between the carbon stored in different land-use systems and the private profitability realized from them. There is no win–win alternative system that combines maximum carbon stocks with maximum farmer profitability. There is a lose–lose or worst-bet alternative: food crops followed by short fallows. But there are two medium-carbon systems that have high levels of farmer profitability: cacao–fruit tree complex

Table 15.3 *ASB matrix comparing the environmental, agronomic, socioeconomic and policy aspects of the alternative land-use systems*

Meta–Land-use systems	*Global environmental concerns*		*Agronomic sustainability*	*Smallholders' socioeconomic concerns*		*Policy and institutional issues*
	Carbon sequestration (above-ground time-averaged; Mt/ha)	Biodiversity (above-ground plant species per plot)	Plot-level production sustainability (overall rating)	Potential profitability (returns to land, US$/ha)	Employment (average labour input; d/ha/yr)	Production incentives at private prices (returns to labour; US$/d)
Forests						
Complex agroforests						
Simple agroforests; intensive tree crops						
Crop–fallow rotations						
Continuous annual crops						
Grasslands, pastures						

Source: Modified from ASB (1996)

agroforests and small-scale oil palm plantations. These are the best-bet alternatives for minimizing the trade-offs between carbon sequestration and farmer profitability, and one can envision how policies or programmes could be established to promote these systems to replace the other systems with low carbon and low profits.

Researching and implementing policies

Once the diverse stakeholders have decided which land-use systems provide the desired combination of production, human welfare and environmental services, such as the example just described, it is necessary to search for policy instruments that can balance these trade-offs and that will lead to a broad-based adoption of those desired systems. Typically, there are few (if any) proven policy or institutional mechanisms to address these environment–development trade-offs. ASB has been involved with various partners in policy research at different levels.

Assessing impact and providing feedback

The last step in the ASB research and development framework is the assessment of the impacts of the options thus devised (Figure 15.2). Although implementation of the various land-use alternatives that have been identified as best bets is still in progress, in its first decade of existence the ASB consortium has had impacts on scientific methods and improved datasets, national research institutions, global forums concerned with poverty, the environment, and deforestation in the tropics, and policy makers. A summary follows.

Impact on science

Perhaps the greatest impact on science has been the research process and framework designed and implemented by ASB. The research framework established the basis for integrated natural resource management research of the CGIAR centres (CIFOR, 2000). The ASB matrix and trade-off analysis provides a way to tackle complex problems and reconcile the interests of different stakeholders. ASB has also shown how the disciplinary strengths in climate change, biodiversity, agronomy, policy reform and adoption can be used in a balanced and positive way, with combined, mutually accepted standard methods.

Other scientific contributions relate to improved methods of data collection and analysis and include improved equations for estimating carbon in young and regrowing trees, where the original equations overestimated carbon by as much as 100 per cent (Ketterings et al, 2001); refinement of the concept of time-averaged carbon for comparing carbon stored in land-use systems with different rotation times (van Noordwijk et al, 1998); validation of the use of plant functional attributes for above-ground biodiversity assessment; methods for assessing below-ground soil biodiversity by the use of functional groups (Swift and Bignell, 2001); and the identification of agronomic sustainability indicators, which is a major advance in the concept of soil quality.

The ASB has enriched the scientific literature substantially, particularly with articles written by national colleagues in international journals, with almost 450 publications by the end of 2003.

Impact on national institutions

The country chapters in part IV of Palm et al (2005) identify many of the effects of the ASB consortium on the collaborating national institutes including implementing the cross-disciplinary research approach, moving much of the work away from experiment stations to farmer fields and communities, and developing meaningful dialogues with policy makers. In addition, the 'south–south' exchange between scientists and policy makers visiting the ASB sites has spurred the imagination of many, resulting in the direct transfer of knowledge generated at one site to another. Such visits and workshops, along with the publication efforts, have 'internationalized' many national partners, but this is an area in which a great deal of potential for impact remains to be tapped.

Impact on policy makers

Substantive and long-term interactions have developed between ASB researchers and national policy makers, based on the solid scientific foundation ASB brings to the discussions.

At the national level, work with the Indonesian Ministry of Forestry resulted in a presidential decree that recognized the property rights of the people managing the complex agroforests on government lands in Sumatra (Fay et al, 1998). ASB has also worked with the Indonesian government to address the devastating forest fires associated with El Niño events. Suggestions include selective restrictions on burning during El Niño events, monitoring and penalizing large companies that misuse fire to clear land, recognizing long-standing land claims to help minimize conflicts over land allocation, reducing or eliminating policies that depress timber prices, and encouraging people who clear land to sell excess wood rather than burn it. At the regional level ASB scientists have promoted enabling policies to support community-based forest management plots with the government of the State of Acre in Brazil and to provide credits for on-farm reforestation with the Ucayali regional government in Peru.

Impacts on global organizations and forums

ASB is now a systemwide programme of the CGIAR and an NGO accredited by the Global Environment Facility. The ASB network of well-characterized benchmark sites in the world's tropical moist forests has attracted the attention of other groups concerned with the issues of poverty, the environment and deforestation at the forest margins. This includes the World Bank, the Asian Development Bank, the International Fund for Agricultural Development (IFAD), many bilateral donors, the Intergovernmental Panel on Climate Change (IPCC), the Millennium Ecosystem Assessment, the Rainforest Challenge Partnership and many others. Many of the approaches and results are being mainstreamed as new projects emerge. The methods for assessing carbon stocks and the improved estimates from the ASB assessment have been recognized and used by the IPCC (Paustian et al, 1997; IPCC, 2001).

External reviews

The ASB consortium has been periodically evaluated by external teams (Eswaran, 1995; Hansen et al, 1997; Technical Advisory Committee [TAC], 2000). The review by the Scientific and Technical Advisory Panel of the Global Environment Facility considered ASB 'exceptional and pioneering in its design, coverage, methodology, organization and scope for transferability and replicability' (Hansen et al, 1997, p1). According to TAC (2000, pxxi), 'the Alternatives to Slash and Burn Programme has gone further than others in relating its research sites to the whole area over which the problem occurs, and in scaling up to the global level in its findings on trade-offs. This is very helpful for the global debate on sustainability issues'. These positive reviews should be balanced with the real limitations of the ASB consortium, including recurring funding shortfalls and the communication challenge of keeping culturally diverse partners informed across the tropical belt.

The way forward

The first decade of the consortium was evaluated in 1999 at a conference in Chiang Mai on environmental services and land-use change. Details of the findings and recommendations are found in van Noordwijk et al (2001b) and Tomich et al (2004). Two of the major gaps that were identified included the assessment of hydrologic, ecological and other environmental services at the watershed or community scale and methods for the various stakeholders to develop workable responses and monitor the impacts of ongoing change.

A range of flexible tools will be identified and developed for communities, local government agencies, NGO activists, research managers, policy makers and other officials. Diverse stakeholders can then better explore their options to influence the individual choices that really determine the rate and pattern of land-use change (van Noordwijk et al, 2001b).

Conclusion

The ASB consortium has contributed scientifically and from a policy perspective to addressing the issues of poverty and deforestation in the humid tropics and has complied with the two Agenda 21 recommendations that formed the reason for its existence: 'Limit and aim to halt destructive shifting cultivation by addressing the underlying social and ecological causes' and 'Reduce damage to forests by promoting sustainable management of areas adjacent to the forests'. But tropical deforestation remains at alarming levels, and so do the poverty and harsh living conditions of most forest margins dwellers. The challenge has been partially met, and the response requires continuous hard work across the research–development continuum throughout the humid tropics. Latin American, African and Asian scientists have learned how to work together and have experienced first hand the benefits of cross-disciplinary and interinstitutional collaboration, working with international scientists, farming communities, government policy makers and leaders of international institutions, and are equipped with the methods and partners to meet this continuing challenge.

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Part IV

Modern Agricultural Reforms

16

Making Soil and Water Conservation Sustainable: From Coercion and Control to Partnerships and Participation

J. Pretty and P. Shah

Modernity and Soil Conservation

Dominant themes

Agriculture has had many 'revolutions' throughout history, from its advent some 10,000 years ago to the renowned 17th–19th-century agricultural revolution in Europe. In the past century, rural environments in most parts of the world have also undergone massive transformations. In some senses, these have been the most far-reaching in their speed of spread of new technologies and the nature of their impacts upon social, economic and ecological systems.

Two guiding themes have dominated these agricultural transformations. One has been the need for increased food production to meet the needs of growing populations. The other has been the desire to prevent the degradation of natural resources, perceived to be largely caused by growing numbers of people and their bad practices. Governments have encouraged the adoption of a wide range of conservation practices and technologies, including soil and water conservation to control soil erosion, grazing management schemes to control rangeland degradation, and exclusion of people from forests and other sites of high biodiversity to protect wildlife and plants.

These forms of agricultural and rural development appear to have been remarkably successful. Both food production and the amount of land conserved have increased dramatically, but both these results have been achieved within the framework of modernization, which is firmly rooted in, and driven by, the enlightenment tradition of positivist science (Habermas, 1987; Harvey, 1989; Rorty, 1989; Kurokawa, 1991). Scientists and planners identify the problem that needs solving,

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such as too much degradation. Rational solutions are proposed, and technologies known to work in a research station or other controlled environments are passed to rural people and farmers. The concern is thus to intervene so as to encourage rural people to change their practices.

Towards coercion with technologies

Central to this process of modernization is the assumption that technologies are universal, and so are independent of social context. New technologies are assumed to be better than those from the past, and so to represent 'progress'. Such a process is usually depicted as linear, with the new and modern displacing the old and 'traditional'. This iconography is powerful in many disciplines, and usually implies that what has gone before is not as good as what we have now.

The assumption of the universality of technologies has inevitably led to greater standardization. As farmers have been made to comply 'in their own best interests', they have done so only by completely changing their own livelihoods, and simplifying their practices to incorporate new technologies. External institutions have acted as if they alone know best.

Such universality of approach or technology leads to homogenization of environments. Where farmers used to grow tens of crop varieties, now they might only grow one or two. Where they used to use a range of biological and physical measures to control soil erosion, now they might only have terraces. Where they used to rely on wild plants and animals for food, medicine and fuel, now they might only rely on markets for these products. Modernization has brought with it the steady erosion of cultural and biological diversity.

This notion is not new. Modernity has sought to sweep away the confusion of diverse local practices and pluralistic functions accumulated over the ages, so as to establish a new order. This order is supposed to bring freedom from the constraints of history, and liberty in the new technologies and practices. This is captured in one of the slogans of the modernist architect, Le Corbusier, who said 'by order, bring about freedom'.

Throughout recent history, institutions concerned with encouraging soil and water conservation have had all the components of modernity. Farmers have been first encouraged, then later coerced, into adopting technologies that are known to work. When these farmers fail to maintain or others spontaneously to adopt these measures, then interventions have shifted to the remoulding of local social and economic environments to suit the technologies.

The contrast with what is required for more sustainable management of natural resources is crucial. Called by some postmodernism (coming after, or contrasting with, modernism), it favours heterogeneity, difference and human capacity as liberating forces. What postmodern traditions have in common is the rejection of 'meta-narratives', or large-scale plans, technologies or theoretical interpretations that purport to have universal application. The central theme is that all groups have a right to speak and act for themselves and their communities, in their own voices, and have their voice accepted as authentic and legitimate. If this is actively sought, then the positive effects on soil and water resources can be remarkable.

Modernization of Soil and Water Conservation in the US, Africa and South Asia

Beginnings in the US

The knowledge that soil erosion was both costly and damaging was first appreciated on a wide scale by agricultural authorities in the US in the 19th century, and in colonial Africa and India in the early part of the 20th century (Bennett, 1939; Hall, 1949; Pretty and Shah, 1994). Rural development policies and practice have generally taken the view that erosion occurs because farmers are poor managers of soil and water.

The style of intervention was first established in the US, where there is still a marked contrast between the enduring success of indigenous soil and water conservation and the approaches adopted by soil conservation authorities. Native American farming cultures farmed with soil and water conservation measures for at least 1500 years in the Greater South West. Farmers of Anasazi, Hohokam, Pueblo, Zuni, Hopi and Papago cultures located fields where water ran off hills, built earthen diversion dams and channels to conduct water, used contour bunds, stone terracing and contour hedges of agave, sited silt traps to produce gully fields, grew crops in mounds and on ridges, and stored run-off in reservoirs (Rohn, 1963; UNEP, 1983; Fish and Paul, 1992).

These combined to produce complex, diverse and productive agricultural systems. At Point of Pines, for example, 2500ha of cultivated land with contour terraces, check dams and bordered gardens supported at least 3000 people for 500 years, and in New Mexico, bordered gardens connected by ditches to vast rain catchment areas supported a population density of 700km^{-2}. Nonetheless, these systems were ignored by the modern conservationists.

At first confined to the southern States, soil conservation spread across most parts of the country in the early to mid-1800s. The principal technology was terracing, but this was supplemented by a wide range of other resource-conserving technologies, including contour ploughing, cross ploughing, green manures and cover crops, drainage ditches, check dams and hillside stripping with hedgerows (Hall, 1949). These technologies were developed, tested and adapted to local conditions by farmers. Until the late 1800s, technologies were derived from 'the experiences of practical planters and farmers'.

However, by the 1870s–1880s, things had begun to change. Terraces of various forms (broad base, bench, Nichols, Mangam, Chisholm and others) became increasingly popular. Although there were objections, e.g. that terraces took too much land out of cultivation and harboured weeds, increasing numbers of advisers, researchers and extensionists began to make wider recommendations based on terraces alone. Researchers at experimental stations, who at first had published bulletins and papers based entirely on the observations and experiences of 'progressive' farmers, later came to advocate technologies solely developed on research stations.

By the early 20th century, agricultural extension agencies and county agents 'built terraces for farmers and instructed them in terrace making and maintenance' (Hall, 1949). In the Alabama, Florida, Mississippi, North and South Carolina and Virginia regions, some 50,000ha were terraced in 1915; this had grown to 283,000ha by 1929. One pioneer county agent, J. F. Hart, laid out 98km of broad base terraces in 1914 alone.

By far the greatest boost to modern conservation ideology occurred when the Dust Bowl disaster struck the southern and southwestern states of Oklahoma, Arkansas, Kansas, Colorado, Texas and New Mexico during the 1930s. In the previous two decades, farmers had been encouraged to move westwards by favourable homestead policies and the high price of wheat (Worster, 1979). In the 1910s, 30,000 farmers each year registered new land holdings in these states, and in 1919 alone, some 4.5 million ha of grassland were ploughed up to grow wheat. By the time the dust storms began, much of the land had been farmed only for a generation. Eventually some 50 million hectares of farmland were said to be severely affected by erosion. Dust and earth blanketed houses and crops, and there were potent images of destruction, the landscape having become 'a vast desert, with … shifting dunes of sand' where there had once been crops (Worster, 1979).

These images of erosion linked farmers' cropping and grazing practices to increased frequency of droughts. The message was clear. Farmers caused land degradation which could lead to national ruin. At the time, several influential writers suggested that whole civilizations had collapsed through neglect of the soil (Bennett, 1939; Jacks and Whyte, 1939). The Head of the US Soil Conservation Service, Hugh H. Bennett, spoke of environmental catastrophe by indicating that 'the ultimate consequence of unchecked soil erosion, when it sweeps over whole countries as it is doing today, must be national extinction' (in Beinart, 1984). Over a relatively short period, policy makers came to treat the problem as so serious that widespread social and institutional action had to be taken.

As a result a federal Soil Conservation Service (formerly the Soil Erosion Service) was established in 1935 as a separate body to the existing extension service. Its agents conducted a national inventory of erosion, so that they could 'help the farmer do things correctly' (in Trimble, 1985). From the start, erosion was seen as a problem arising out of bad farming practices that had to be corrected. However, to demonstrate the efficacy of the approach, the SCS needed large amounts of land to practise the new large-scale engineering measures. As few agreements came from private farmers, they selected Navajo reservations on which to experiment (Kelly, 1985).

The SCS constructed physical measures and enforced compulsory destocking of sheep and goats. College graduates did the technical work, and local Navajos worked as labourers, but the project provoked an intense negative reaction, not only to soil conservation but also to all government programmes. Anthropologists discovered that the local people were not against soil conservation, but were opposed to the way it was being implemented (Kelly, 1985). They took exception to the locations of the measures, as these interfered with other activities. It was not a lack of interest that prevented them from maintaining or repairing the structures and earthen dams, but rather that the measures had been constructed with heavy equipment to which they had no access, and over which they had no control.

Conflict over budgeting and approach continued to hamper the SCS. Their approach was vigorously opposed by the extension service, whose agents at county level and in land-grant colleges had a good knowledge of the diversity of local conditions. The SCS applied terracing technology widely, whilst local agents argued for locally adapted and appropriate technologies, but the dissenting voices were ignored. Sauer was one of the few who indicated that construction without maintenance did more harm than good: 'the present erosion crisis is the result primarily of the introduction of terracing, originally thought of as protection against erosion' (Sauer, 1934, in Trimble, 1985).

Transfer to Africa

The pattern of intervention was repeated by colonial authorities in Africa. Erosion was first recognized as a problem as early as the 1870s, although it was not until the early part of the 20th century that concern grew over farming as practised by both indigenous people and colonial farmers. At first, farmers were encouraged to adopt soil conservation practices through publicity bulletins extolling the virtues of contour ploughing and grass strips, by establishing demonstration plots, and via local legislation (Stocking, 1985; Gichuki, 1991), but few farmers adopted the technologies, even though groups were taken to demonstration farms to see the benefits of the new farming practices.

New grazing management systems of enforced enclosure of grazing lands, developed in Texas, were also implemented. Again potent images of erosion spurred these efforts. In Kenya, Huxley (1960) described 'gullies 15–20 feet deep … in places, the landscape seems as dead as the moon's' in the west, and elsewhere the 'land is gashed … scraped bare, pounded into dust by the hoofs of little cattle and greedy goats'. It was clear to officials that local people were to blame. They sought technical guidance from the US, and brought back recommendations for large-scale conservation intervention. There were occasional dissenting voices. Writing in 1930, Sampson drew attention to indigenous methods of cultivation designed to check erosion, particularly mounding and ridge-and-furrowing systems on the contour. He indicated that local farmers 'fully realize the losses caused by erosion and consequent soil exhaustion, and their methods are well worth studying not only for themselves, but as a guide to those who seek to improve on them' (Sampson, 1930), but these sentiments were rare.

When these new soil conservation efforts proved to be too costly to sustain, particularly where mechanization was required, administrators increased the use of local labour rather than adapt the technologies (Anderson, 1984). They also put together the components of good conservation practice into farm plans. These were laid out on a blueprint chart showing what every field was to grow for 10 years, with all contours marked, the locations for woodlots, paddocks and homestead, and where to plant cash and food crops.

All of this required the monitoring of farming practices to ensure compliance. The final stage of control was achieved by the compulsory resettlement of farmers to centralized linear settlements where they could be observed more easily. In Kenya, more than one million people were moved in the mid-1950s to some 850 new linear villages (Huxley, 1960). Officials, proud of the new neatness and order, commented that farms of one village in Zimbabwe (then Rhodesia), were 'all in lines and look very nice' (Alvord, in Beinart, 1984).

This was a complete contrast to the traditional way villages in East and Southern Africa are arranged. Now many of the straight paths and tracks readily became gullies, as they concentrated water flow down slopes. The contrast again with traditional practices, where paths were laid out in zig-zag patterns, is significant (Wilson, 1989). Soil and water conservation had extended to the remoulding of all aspects of rural life.

Soil and water conservation in South Asia

As in the US and colonial Africa, there is a long history of both recognizing and ignoring local conservation practices in South Asia. The earliest accounts show that in 1888 some 1200ha of ravines in Uttar Pradesh were treated with conservation measures to protect the adjoining town of Etawah from water erosion. This was followed by tree planting, and fanners were coerced into adopting zero-grazing for livestock. The programme was acclaimed a success (PRAI, 1963).

At the same time, though, visitors were seeing local innovation and skills. Professor Voelcker, a consultant to the Royal Agricultural Society of England, visited India in 1889 and wrote in his report: 'Nowhere would one find better instances of keeping land scrupulously clean from weeds, of ingenuity in device of water raising appliances, of knowledge of soils and their capabilities as well as the exact time to sow and reap, as one would in Indian agriculture. It is wonderful, too, how much is known of rotation, the system of mixed crops and of fallowing. Certain it is that I, at least, have never seen a more perfect picture of careful cultivation, combined with hard labour, perseverance and fertility of resources' (in Dogra, 1983).

By 1928, the Royal Commission on Agriculture had recognized soil erosion as a problem of special importance, and had noted work already in progress: 'In the United Provinces, the main remedy for soil erosion has been sought in the afforestation of the ravine tracts. In Bombay [now Maharashtra State], the measures adopted to prevent soil erosion are terracing of land and the construction of earth and stone embankments.' The Famine Enquiry Commission of 1945 later indicated that the large-scale experiments conducted in Bombay had produced results sufficiently satisfactory to warrant contour bunding on a large scale. In Bombay, conservation work started in 1939 when the scheme for bunding and dry farming development was sanctioned. A similar act was passed in Madras in 1949 for contour trenching and bunding.

In the years that followed, conservation structures were constructed solely by the State. Although these were initially effective, it was soon realized that the approach could not be extended because of the high cost of operation and maintenance. The lack of involvement of farmers was also understood to be a problem, but at the same time they were considered to be ignorant. Most technical literature emanated from the US, and training opportunities for professionals were again on US Soil Conservation Service programmes.

The technocratic model of development of watersheds became the predominant approach at this stage and formed the basis for the formulation of 5-year plans and allocation of resources for soil conservation. These began with the objective 'to govern, regulate and administer the use of land both under private and public ownership, so as to facilitate the optimum use of land resources in the interests of the present and future generations' (Planning Commission, 1964), but the plans consisted of technical and engineering solutions with repeated emphasis on the education of farmers who had to be made aware of the new technologies. Problems with implementation and maintenance followed. When cultivators in Madhya Pradesh were reluctant to undertake earthwork, the department entrusted it to contractors. The contour bunding was completed with bulldozers, with no attention paid to the interests of farmers. In Maharashtra, Gujarat and Mysore, farmers were said to have taken to large-scale contour bunding, but it later became clear that 'the aspects of conservation farming practices or follow-up are neglected. As a consequence … the project is not serving the purpose for which it was set up' (Planning Commission, 1964).

Soil conservation continued with a technocratic emphasis. Between 1963 and 1990, national initiatives spent Rs4215 million (equal to US$149 million at current prices) on soil conservation in River Valley Projects (Fernandez, 1993), but farmers did not perceive any benefits from the structures. Indeed, many levelled and destroyed the measures because of the loss of cropland to conservation and the increase in observed soil erosion. The lack of compliance encouraged authorities to seek legal solutions. Several states passed laws to prevent 'wilful' destruction and to allow specified 'improvements' to be made on farmers' fields, and allocated the costs of these improvements between the farmers and the state. In some places, provisions were made for compulsory treatment of the fields of farmers refusing land treatment. In many cases this led to increased alienation with, for example, people uprooting plantations and destroying fencing and conservation measures.

Fundamental Contradictions of Recent Soil and Water Conservation Programmes

The 'complete' conservation technology package

Like other practices in agricultural development, most soil and water conservation programmes have begun with the notion that there are technologies that work, and it is just a matter of inducing or persuading farmers to adopt them. Yet few farmers are able to adopt whole packages of external technologies without considerable adjustments in their own practices and livelihood systems. To some, this may not be a problem; to the majority, it is a major impediment to adopting conservation technologies and practices.

A recent study of upland agriculture projects in six countries of South-East Asia found that farmers have not adopted resource-conserving technologies on a significant scale for a wide variety of social, economic and biological reasons (Fujisaka, 1991). Contour hedgerows, bench terraces, earth bunds, multiple cropping, legumes, perennial crops, contour tillage and alley cropping have all been introduced to farmers as they offer the opportunity for increased yields on a sustainable basis. In some cases, farmers' practices were ignored; in others the main problems for farmers, such as weeds, were not identified. Elsewhere, insecure land tenure prevented farmers investing in trees or terracing; in other places short-term incentives paid to farmers distorted local perceptions of conservation.

The problem is that the imposed models look good at first, and then fade away. Alley cropping, an agroforestry system comprising rows of nitrogen-fixing trees or bushes separated by rows of cereals, has long been the focus of research (Kang et al, 1984; Attah-Krah and Francis, 1987; Lal, 1989). Many productive and sustainable systems, needing few or no external inputs, have been developed. They stop erosion, produce food and wood, and can be cropped over long periods, but the problem is that very few, if any, farmers have adopted these alley cropping systems as designed. Despite millions of dollars of research expenditure over many years, systems have been produced which are suitable only for research stations (Carter, 1995).

There has been some success, however, where farmers have been able to take one or two components of alley cropping, and then adapt them to their own farms. In Kenya, for example, farmers planted rows of leguminous trees next to field boundaries, or single rows through their fields, and in Rwanda, alleys planted by extension workers soon became dispersed through fields (Kerkhof, 1990).

However, the prevailing view tends to be that farmers should adapt to the technology. Of the Agroforestry Outreach Project in Haiti, it was said that 'Farmer management of hedgerows does not conform to the extension program… Some farmers prune the hedgerows too early, others too late. Some hedges are not yet pruned by two years of age, when they have already reached heights of 4–5 metres. Other hedges are pruned too early, mainly because animals are let in or the tops are cut and carried to animals… Finally, it is very common for farmers to allow some of the trees in the hedgerow to grow to pole size' (Bannister and Nair, 1990). The language used clearly indicates that what farmers are doing is bad. Yet it could also be interpreted as good for sustainability: farmers were making their own adaptations according to their own needs.

Lack of maintenance by local people

Despite decades of effort, soil and water conservation programmes have had surprisingly little long-term success in preventing erosion. On paper, the quantitative achievements of some programmes can appear impressive. Throughout the world, terraces have been built, trees planted and farmers trained on a massive scale. In Africa, huge areas of land have been protected in the short term by conservation measures (Table 16.1).

However, these have not been long-term successes. In virtually all these sites, structures and practices have not persisted. Projects assume that maintenance will occur. Yet as farmers are treated at best as labourers for construction, they have few incentives to maintain structures or continue with practices that they neither own nor have had a say in designing. All too often, impressive new structures and practices slowly disappear, leaving little evidence of interventions and institutions.

This was recognized in the early days of the SCS in the US. A 1941 study of some 520 terraced fields on 5000ha in the south found that most terraces had been 'improperly constructed' and poorly maintained (Carnes and Weld, 1941). The terraces had been constructed by the SCS, yet 83 per cent were not being maintained by the farmers on whose fields the measures were situated.

Sometimes, successes are reversed almost immediately. In an evaluation of World Food Programme-supported conservation in Ethiopia, the extent of the terracing was quoted as being 'impressive', yet monitoring found 40 per cent of the terracing broken the year after construction (SIDA, 1984). The project had expected that local people would bear all the costs of maintenance. Another example comes

Table 16.1 *Extent of large-scale soil conservation programmes in Africa*

Burkina Faso	120,000ha of graded bunds constructed 1962–1965
Ethiopia	1–5 million km of stone and soil terraces and bunds constructed on 300,000ha, and 80,000ha closed off from local people during the late 1970s to 1987
Lesotho	All the uplands were said to be protected by buffer stripping by 1960
Malawi (then Nyasaland)	118,000km of bunds were constructed on 416,000ha between 1945 and 1960
Malawi	288,000ha terraced between 1968 and 1977
Rwanda/Burundi	750,000ha terraced and planted with trees to 1960
Swaziland	112,000km of grass strips laid out to 1950
Tanzania	125,000ha of Kondoa completely destocked of cattle to 1979 to encourage hillside regeneration
Zambia (then North Rhodesia)	Half the native land in eastern province was said to be protected by contour strips by 1950

Sources: Stocking, 1985; Marchal, 1986; Reij, 1988; IFAD, 1992 from the Yatenga region of Burkina Faso, where 120,000ha of earth bunds constructed at high cost with machine graders in the early 1960s have now all but disappeared (Marchal, 1978, 1986). In the Majjia and Badéguicheri valleys of Niger, most of the 6000ha of earth bunds constructed between 1964 and 1980 are in an advanced state of degradation (Reij, 1988). In Sukumuland, Tanzania, where contour banks, terraces and hedges were forced upon farmers in the 1950s, almost no evidence remained of these conservation works by the early 1980s, and now 'erosion is extremely severe' (Stocking, 1985).

Graded and contour bunds developed for large-scale farming in the US are still widely applied in programmes in India. Even under heavy subsidies, most small farmers reject them (Kerr and Sanghi, 1992). These bunds leave corners in some fields, and so there is a risk of losing the piece of land to a neighbour. The central water course for drainage benefits only some farmers, while damaging the land of others. Contour farming is inconvenient when farmers use multi-row implements, and so is only suitable where the holding is large and tractors are available. Contour bunding without facilities for dealing with surplus water commonly breach, again concentrating water flow that quickly forms gullies. Therefore, it is not uncommon for entire bunds to be levelled as soon as project staff shift to the next village (Sanghi, 1987; Fernandez, 1993).

In Cape Verde, the state takes responsibility for erosion control by paying farmers to work on their own land. The result is that traditional practices are ignored as farmers take the money without influencing the project. *Socalco* terraces, for example, are built from top to bottom of steep slopes, with the result that foundations are often left hanging in the air (Haagsma, 1990). As Haagsma put it 'this does not stimulate … good cooperation between farmers and MDRP [the project]. It is difficult to eradicate the attitude "MDRP knows best".'

A major project in Niger was described by the implementing agency in this way: 'People's participation is the power behind the Keita project. From decision-making – to planning – to action: local farmer-livestock owners have been consulted and actively taken part in every step' (FAO, 1992). Although some 2.76 million work-days were paid for with World Food Programme rations, which served as 'incentives to participate in land reclamation and training courses offered by the project', no farmers apply the technologies to their own lands, and replicability is close to zero (IFAD, 1992).

In Ethiopia, where 1.5 million km of terracing were constructed during the 1980s with food for work, participation was 'either compulsory via peasant association campaigns or paid through food for work' (SIDA, 1984). A total of 34.3 million person-days of work was devoted to conservation, involving the 'cooperation of some 8000 Peasant Associations' (FAO, 1986, in Östberg and Christiansson, 1993). Apparently, 'farmers' participation was shown by their contributions of labour for infrastructure development', and the project expected these structures to be maintained because 'training … will help in sustaining activities when the donor pulls out. The privilege of being trained will keep the individual responsible in the activities he (sic) was trained for' (reported in Oxfam, 1987).

Most soil and water conservation projects have paid and continue to pay local people in cash or food for their 'participation' (Kerr, 1994). But this is clearly self-defeating. According to Reij (1988): 'practice shows that where people are paid for soil and water conservation, the end of the project almost invariably leads to a stop in the construction of conservation works'.

More terracing yet more erosion

As a result of programmes not involving farmers in conservation, many have actually increased the amount of soil eroding from farms. Local people whose land is being rehabilitated have found themselves participating for no other reason than to receive food or cash. Seldom are the structures maintained, and so conservation works rapidly deteriorate, accelerating erosion instead of reducing it. If performance is measured over long periods, the results are extraordinarily poor for the amount of effort and money expended (Shaxson et al, 1989; Hudson, 1991; Reij, 1991; Shaxson, 1996).

Poorly designed structures cause erosion. Yet throughout Africa, little account has been taken of how more terracing can lead to more erosion. In the early 20th century, erosion in Lesotho was not a serious problem in cultivated fields, as grassed field boundaries were well developed and maintained (Showers, 1989). Yet the authorities ignored this indigenous practice, and installed contour banks. Local people did not approve, because these reduced the size of fields and were easily breached, causing gullies to develop leading to more erosion. The administration attributed these gullies to 'unusual weather' (Showers and Malahleha, 1990).

Elsewhere in southern Africa, the first anti-erosion measures introduced in the early 1930s were large ridge terraces and bunds, but these imported measures permitted storm water to break through at vulnerable points. Careless construction made them susceptible to bursting, and locals came to believe that 'gully erosion was caused by the government' (Beinart, 1984).

Narrow-based terraces were introduced into Kenya from the US in 1940 (Gichuki, 1991). For 15 years they were widely used. By 1947, some 4000ha were being protected each year, and this rate continued until 1956–1957. However, these terraces were found to fill up with sediments quickly, were impossible to maintain, and even began to aggravate erosion, and so by 1958 the number falling into disrepair was exceeding new construction. By 1961, some 20,000ha had fallen into disrepair. Eventually, the authorities recognized the problems and L. H. Brown, the chief agriculturalist, issued a memorandum in 1961 saying that 'narrow-based terraces should be abandoned as policy … we should move to strips of vegetation, preferably grass' (in Wenner, 1992).

Bad contour ridging in the 1960s was worse than none at all in Zimbabwe (then Rhodesia), where farmers say the compulsory construction of ridges caused siltation of rivers. The ridges connected whole fields and drained in a single drainage line. During severe storms, they concentrated water into powerful and fast-moving bodies that caused great damage (Wilson, 1989). The same thing has occurred with cut-off drains in Kenya. Their function was to intercept and divert storm water, but many were constructed in a way that caused erosion. As one review put it: 'The most severe mistakes were that cut-off drains were laid and constructed on the wrong sites. They were designed with steep gradients… The water is discharged into gullies which are deepening. The channel ridges were bare… All these factors have made the structures more dangerous than useful. More problems were created. Gullies have widened, soil was eroded and crops destroyed' (Hunegnaw, 1987).

More recently, in Malawi, the Lilongwe Land Development Programme (1968–1977) terraced some 288,000ha of land using heavy earth-moving machinery, but as farmers had few incentives to maintain these terraces, many of the diversion ditches silted up and breached to form severe gullies. The same story was repeated in nearby Swaziland from 1977–1983, where the Rural Area Development Programme built terraces with heavy machinery (IFAD, 1992). These destroyed all previous practices, but none of the new ones were maintained.

In Oaxaca, Mexico, a large-scale government soil conservation programme is also establishing contour bunds based on the US models. It is an area noted in the 1970s and 1980s by various 'expert' missions as having 'massive soil erosion' and 'the world's worst soil erosion', but recent evidence is suggesting that erosion has only become serious following the imposing of terraces and bunds (Blackler, 1994). Rill erosion has been recorded within one year of their establishment, and degradation has been so severe that less than 5 per cent of the bunded area is cropped.

Induced social disruption

The impact of these programmes has been to make many things worse. A failure to involve people in design and maintenance can have considerable long-term social impacts. The enforced terracing and destocking in Kenya, coupled with the use of soil conservation as a punishment for those supporting the campaign for independence, helped to focus the opposition against both authority and soil conservation (Gichuki, 1991; Pretty and Shah, 1994). After independence, this led to the deliberate destruction of many structures because of their association with the colonial administration (Anderson, 1984).

In Rwanda, the massive terracing programme using forced labour of the Belgian administration prior to 1960 created such negative feelings towards soil conservation that no further activities were possible until the late 1970s (Musema-Uwimana, 1983). In the Uluguru mountains of Tanzania, where ladder and step terraces were common, the Uluguru Land Usage Scheme introduced compulsory bench terracing in the 1950s – the scheme had to be abandoned after serious riots by local people (IFAD, 1992). Elsewhere in Tanzania, the HADO project completely removed livestock from whole communities, with tens of thousands of animals removed from individual districts. Such a policy was only possible 'after mustering the cooperation of the ruling party and government machinery at village, district, regional and national levels. Inevitably some of the actions necessary to reverse soil degradation processes are a bitter pill to swallow.' Despite this, the project staff believed that: 'the favourable results of destocking have sparked an interest in taking similar measures, particularly in the region's other districts' (in Mndeme, 1992).

In Somalia, a large FAO-funded project constructed dams during the 1970s to check gullies, but because of poor construction, many collapsed or diverted the floods, so accelerating gully erosion instead of preventing it. This induced widespread disenchantment amongst local people for all conservation projects that followed (Reij, 1988). Such attitudes remain a critical constraint for many current soil conservation efforts.

Elements of Sustainable and Participatory Soil and Water Conservation Programmes

A brief summary of impacts

By most performance measures, conventional conservation programmes have been remarkable failures. Little has changed over the course of this century. Large sums of money have been spent in the name of environmental protection encouraging and coercing farmers to adopt conservation measures, but poor implementation by outside technical teams means that few structures persist, so causing erosion rather than preventing it. The result has been widespread discrediting of conservation projects and programmes in the eyes of the rural people themselves. However, the issue and costs of soil erosion will not go away. The challenge remains enormous.

There is now emerging evidence that regenerative and resource-conserving technologies and practices can bring both environmental and economic benefits for farmers and communities (Hinchcliffe et al, 1995; Pretty, 1995a; Shaxson, 1996). Importantly, these breakthroughs have come on fanners' fields and in rural communities. It has long been known that resource-conserving technologies will work in research stations, but somehow they have not been widely adopted by farmers. Now, as a result of agricultural professionals increasingly working with and learning from farmers, new productive options are being developed (Table 16.2).

There are now a growing number of programmes that have been sufficiently successful to suggest the need for application on a much wider scale (Shaxson, 1996). All of these successes have elements in common. Farmers have been a central part of the process of innovation and adaptation of resource-conserving technologies. There has been action by groups and communities at local level, with farmers becoming experts at managing farms as ecosystems, and at collectively managing the watersheds or other resource units of which their farms form a part. There have also been supportive and enabling external government and/or non-government institutions, often working in new partnerships with new participatory

Table 16.2 *Sustainable soil and water conservation highlights*

Australia	More than 2000 community groups involving one third of all Australian farmers are now able to tackle local environmental problems that cannot be solved within a single farm boundary; new forms of collective action are emerging, with farmers trying to be visionary about the future rather than victims of circumstance; these land-care groups are formally linked to existing institutions, including national-level policy makers
Brazil	A government programme, EPAGRI, in Santa Catarina has pioneered the use of more than 60 species of green manures and cover crops through its micro-watershed programme; some 38,000 farmers have been reached, with yields more than doubling and farmers needing less labour for weeding and ploughing
Burkina Faso	A government programme, Projet d'Aménagement de Terroirs et Conservation de Ressources (PATECORE), working with farmers in 240 villages has so improved 10,000ha of unproductive drylands with conservation measures that the average family's food deficit of 645kg $year^{-1}$ at the beginning of the programme has been turned around to a 150kg surplus
Honduras	Green manures and cover crops have so improved organic matter in soils that crop yields have more than tripled for several thousand farmers
India	A wide range of non-government and government initiatives throughout India have led to substantial benefits for local people. New linkages between external agencies and local communities are resulting in the recovery of barren lands, an average doubling of crop yields, increased crop diversity, improved well-water availability, greater social cohesion, alternative forms of credit management by local groups, and the federation of local groups to ensure influence over higher-level institutions and political interests. Notable successes are in Karnataka (by MYRADA), Tamil Nadu (by The Society for People's Education and Economic Change with local government), Rajasthan (by Government of Rajasthan), Uttar Pradesh (by Doon Valley Integrated Watershed Management Programme), Gujarat (by Aga Khan Rural Support Programme) and Maharashtra (by Indo-German Watershed Development Programme)
Kenya	The government is pioneering a participatory approach to soil and water conservation; with the mobilization of communities, some 100,000 farms are now conserved each year, on which there have also been increases in food production, diversification into new enterprises, reduction in resource degradation, and increases in labour demand and land prices
Lesotho and Malawi	The innovative rural action learning areas initiative is building upon the best practices of farmers and linking them to research and extension organizations; new forms of collaboration are emerging between institutions throughout southern Africa, with a particular focus on learning loops to improve performance

Table 16.2 *(continued)*

Philippines	Upland rehabilitation programmes run by the Mag-uugmad Foundation, the Farm Management Institute of the Visayas State College (FARMI) and the International Institute for Rural Reconstruction (IIRR) have shown the value of farmer-based extension systems, in which farmer groups experiment with and spread new technologies, with the result that agricultural yields have more than doubled, soils have been conserved, and local economies regenerated

Sources: GTZ, 1992; Balbarino and Alcober, 1994; Campbell et al, 1994; Cerna et al, 1994; Devavaram, 1994; Fernandez, 1994; Freitas, 1994; Kiara et al, 1994; Krishna, 1994; Shah and Shah, 1994; Hinchcliffe et al, 1995

methodologies, which have reoriented their activities to focus on local needs and capabilities.

Value local knowledge and technologies

Before deciding on the course of action, projects should start with what people know and do well already. The problem with agricultural science and extension is that it has poorly understood the nature of 'indigenous' and rural people's knowledge. For many, what rural people know is assumed to be 'primitive' and 'unscientific', and so formal research and extension must 'transform' what they know in order to 'develop' them. An alternative view is that local knowledge is a valuable and underutilized resource (Chambers et al, 1989; Röling and Engel, 1989; Warren, 1991; Scoones and Thompson, 1994). Within this context, understanding processes of agricultural innovation and experimentation is an important new focus.

It is now well documented that for several thousand years farmers have conserved soil and water to sustain agricultural production in many varied contexts. Across North Africa to the Negev desert, farmers under Roman rule created a settled agriculture that lasted for several hundred years in semi-arid conditions (Evaneri et al, 1971; Barker and Jones, 1982). Elsewhere in Africa and the Middle East, at least 40 different indigenous systems of soil and water conservation have been recorded (Reij, 1991; IFAD, 1992; Critchley et al, 1994).

A major problem is that professionals disregard indigenous knowledge and technologies all too easily. In Niger, traditional stone lines in the Ader Doutchi Maggia can be observed by anyone driving on the main road from Konni to Tahoua (Reij, 1991). Despite the presence of conservation projects in the region since the early 1960s and visits by many 'experts', no reports contain reference to these stone lines. In both Niger and Burkina Faso, farmers prefer stone lines and bunds, yet all major projects have constructed only earth bunds, which of course have not been maintained by local 'beneficiaries' (Reij, 1991).

In the medium to high rainfall red-soil areas of Andhra Pradesh and Karnataka, the government recommends graded bunds and contour farming for soil and moisture conservation. Farmers, however, use a diverse mix of technologies, including field boundary bunds and drains with waste weirs, grasses on field bunds and drains, short-term fallowing, criss-cross ploughing, seeding across slope, tied ridging, frequent interculture, deep ploughing in summer, and compartmental bunding (Kerr and Sanghi, 1992).

One example of soil and water conservation measures used widely by farmers, yet commonly ignored by professionals, are silt traps and gully fields. Stones are placed across gullies or valleys to capture nutrients, silt and moisture. The principle is to capture run-off from a broad catchment area and concentrate it in a reduced area, so transforming meagre rainfall into utilizable soil moisture. As water slows, any suspended debris is deposited, helping to form organic-rich soils. These gully or deposition fields have been recorded in India (Chambers, 1991; Shah et al, 1991; Prem Kumar, 1994); Pakistan (personal observations (1992, 1994, 1995) in Punjab and northwest Frontier Provinces), Ethiopia (ERCS/IIED, 1988); Mexico, known as *atajadizos*, *trincheras* and *trancas* (Johnson, 1979; Blackler, 1994); Nepal (Tamang, 1993); and Burkina Faso (Reij, 1988).

A well-maintained silt trap creates a flat, fertile and moist field with a micro-environment quite unlike the surrounding area. Crops can thus be grown which may be of higher value than field crops on nearby drylands, such as rice in India, wheat and rapeseed in Pakistan, sorghum and rice in Burkina Faso, and *chat* and coffee in Ethiopia. Agriculture in these gully fields is productive and dependable (Griffin and Dennis, 1969; Shah et al, 1991). In Burkina Faso, sorghum yields can range between 970 and 2670kg ha^{-1}, and in some fields rice can be grown (Reij, 1988). Farmers in Gujarat have been able to grow high-yielding varieties of lowland paddy, and in some cases achieve yields higher than irrigated regions in dryland areas (Shah, 1994). Farmers additionally benefit from these traps as groundwater levels are raised and damage to crops on the downstream side is reduced (Johnson, 1979; Reij, 1988).

The key element is that these technologies are intrinsically incremental systems, in which farmers add to the height of their structures year by year. Stones are often bedded into the upper surface of spillway aprons and walls to provide support for the next layer, in order to keep the wall above the level of the accumulating alluvium. Wilken (1987) reports the narrative account of an Otomí farmer of Hidalgo, Mexico:

> An *atajadizo* isn't built all at once. Usually a farmer starts with a low wall across the path of an *arroyo* (gully). It takes a few years until the water has brought down enough debris and soil to level with the top of the wall. Then, the farmer will build up the wall a bit more, and so on, little by little until s(he) has built up a tall strong wall and a large level field. A well-made *atajadizo* is level so that the trapped water will cover all parts of the field evenly. It may be necessary to level the field by hand and, also, to tear down parts of the gully in order to enlarge the field. A well-made *atajadizo* always has a wall that is higher than the field behind it. This is necessary because water must be trapped so that it can soak into the field … There is no need to fertilize an *atajadizo* because every rainy season the water brings down new debris and soil.

Enhance farmers' capacity to innovate

It is important to seek and encourage the involvement of farmers in adapting technologies to their local conditions. This is a reversal of the normal modes of research and technology generation, as it requires interactive participation between professionals and farmers. Participatory technology development is a process in which the knowledge and research capacities of farmers are joined with those of scientific institutions, whilst at the same time strengthening local capacities to experiment and innovate (Reijntjes et al, 1992). Farmers are encouraged to generate and evaluate indigenous technologies and to choose and adapt external ones on the basis of their own knowledge and value systems.

Important evidence comes from a variety of soil conservation and agricultural regeneration programmes in Central America (Bunch and López, 1994). The Guinope (1981–1989) and Cantarranas (1987–1991) programmes in Honduras and the San Martin Jilotepeque (1972–1979) programme in Guatemala were collaborative efforts between World Neighbors and other local agencies. They all began with a focus on soil conservation in areas where maize yields were very low (400–660kg ha^{-1}), and where shifting cultivation, malnutrition and outmigration prevailed. All show the importance of developing resource-conserving practices in partnership with local people.

There were several common elements. All forms of paternalism were avoided, including giving things away, subsidising farmer activities or inputs, or doing anything for local people. Each started slowly and on a small scale, so that local people could meaningfully participate in planning and implementation. They used technologies such as green manures, cover crops, contour grass strips, in-row tillage, rock bunds and animal manures that were appropriate to the local area, and which were finely tuned through experimentation by and with farmers. Extension and training was done largely by villager farmers who had already experienced success with the technologies on their own farms.

There are few published studies that give evidence of impacts some years after the outside interventions ended. In 1994, however, staff of the Honduran organization COSECHA (Associatión de Consejeros una Agricultura Sostenible, Ecológica y Humana) returned to the programme areas and used participatory methods with local communities to evaluate subsequent changes (Bunch and López, 1994). The first major finding was that crop yields and adoption of conserving technologies had continued to grow since project termination (Table 16.3). Surprisingly, though, many of the technologies known to be 'successful' during the project had been superseded by new practices. Had the original technologies been poorly selected? It would appear not, as many that had been dropped by farmers are very successful elsewhere. The explanation would appear to be that changing external and internal circumstances, such as changing markets, droughts, diseases, insect pests, land tenure, labour availability, political disruptions and so on, had reduced or eliminated their usefulness.

Altogether, some 80–90 successful innovations were documented in these 12 villages (not counting the failures). There had been innovations in virtually all the

Table 16.3 *Changes in adoption of resource-conserving technologies, maize yields and migration patterns in three programmes in Central America during and after projects*

	At initiation	*At termination*	*In 1994*
No. of farmers with technologies (and no. of villages with technology)			
Contour grass barriers (12)	1	192	280
Contour drainage ditches (12)	1	253	239
Contour rows (6)	0	100	245
Green manures (7)	0	35	52
Crop rotations (8)	12	209	254
No burning fields or forests (7)	2	160	235
Organic matter as fertilizer (8)	44	195	397
Yields of maize (kg ha^{-1})			
San Martin	400	2500	4500
Guinope	600	2400	2730
Cantarranas	660	2000	2050
Migration			
San Martin			
San Antonio Correjo	65	nd	4
Las Venturas	85	nd	4
Guinope: 3 villages	38	0	(2)
Cantarranas: 3 villages	nd	10	(6)

Note: 12 villages sampled from the total of 121 in the three programme areas; (2) and (6) indicate in-migration of families; nd = no data.

Source: Bunch and López, 1994

villages. In one Honduran village, Pacayas, there had been 16 innovations since termination, including four new crops, two new green manures, two new species of grass for contour barriers in vegetables, chicken pens made of king grass, marigolds for nematode control, use of lablab and velvet bean as cattle and chicken feed, nutrient recycling into fishponds, human wastes in composting latrines, napier grass to stabilize cliffs, and home-made sprinklers for irrigation.

Technologies had been developed, adopted, adapted and dropped. The study concluded that the half-life of a successful technology in these project areas is 6 years. Quite clearly the technologies themselves are not sustainable. As Bunch and López (1994) have put it 'what needs to be made sustainable is the process of innovation itself'.

A similar picture has emerged in Gujarat, where many farmers have developed new technical innovations after support for undertaking simple treatment measures on their own land. Farmers have introduced planting of grafted mango trees and bamboo near embankments, so making full use of residual moisture near gully traps. They have also introduced cultivation of vegetables, such as brinjal and lady's finger, other leguminous crops and tobacco in the newly created silt traps. This has increased production substantially, particularly in poor rainfall years, as well as diversifying production. Most of these innovations and adaptations have been introduced and sustained with support from the local network of village extensionists (Shah, 1994).

Build up and strengthen local institutions

The success of sustainable soil conservation depends not just on the motivations, skills and knowledge of individual farmers, but on action taken by local groups or communities as a whole. Yet throughout the history of agricultural development, it has been rare for the importance of local groups and institutions to be recognized. Development professionals have tended to be preoccupied with the individual, assuming that the most important decisions affecting behaviour are made at this level. As a result, the effectiveness of local groups and institutions has been widely undermined. Some have struggled on. Many others have disappeared entirely.

Studies of agricultural development initiatives increasingly show that people who are already well organized, or who are encouraged to form groups, and whose knowledge is sought and incorporated during planning and implementation, are more likely to continue activities after project completion. If people have responsibility, feel ownership and are committed, then there is likely to be sustained change.

The process of establishing self-reliant groups at local level must be an organic one (Ostrom, 1990; Röling, 1994). In the early stages, groups focus on establishing agreed rules for management and decision making. These can then be used by members as a vehicle to channel information or loans to individual members. Confidence grows once small homogeneous groups have successfully achieved initial goals, such as the conservation of a hillside. It is then common for members to turn their attention to development activities that will benefit themselves as well as the community at large. This may involve the nomination of individuals to receive specialized training, such as in soil and water conservation, pest control, veterinary practice, horticulture or book-keeping, so that they will be able to pass knowledge back to the whole group in their new role as paraprofessional or extension volunteer (Shah and Shah, 1994; Pretty, 1995a). Alternative institutional mechanisms such as farmer-to-farmer extension and village-managed extension systems have helped to scale up soil and water conservation effectively.

As confidence grows with success, and resource bases expand and group activity can evolve to an entrepreneurial stage where common action projects are initiated. These are held under group ownership and might comprise investing in fruit orchards, afforesting an upper watershed, terracing a hillside, investing in agricultural tools and draught animals for hire to the community, community pest management, organizing community-run wildlife utilization schemes, and building housing for poor families (Murphree, 1993; Fernandez, 1994; Shah and Shah, 1994). These group activities benefit group members as well as having a wider ecological and social impact, and become the mechanism for sustained conservation activity. Local institutions help to mobilize local resources, particularly savings to get access to credit and undertake joint marketing of agricultural produce (Fernandez, 1994; Shah, 1994).

Adopt participatory methods in soil conservation programmes

There is a long history of participation in agricultural development, and a wide range of development agencies, both national and international, have attempted to involve people in some aspect of planning and implementation. In recent years, there have been an increasing number of comparative studies of development projects showing that 'participation' is one of the critical components of success. It has been associated with increased mobilization of stakeholder ownership of policies and projects, greater efficiency, understanding and social cohesion, more cost-effective services, greater transparency and accountability, increased empowering of the poor and disadvantaged, and strengthened capacity of people to learn and act (Reij, 1988; Finsterbusch and Wicklen, 1989; Bagadion and Korten, 1991; Cernea, 1991; Guijt, 1991; Pretty and Sandbrook, 1991; Uphoff, 1992; Narayan, 1993; Scoones and Thompson, 1994; World Bank, 1994; Pretty, 1995a, 1995b; Thompson, 1995).

As a result, the terms 'people's participation' and 'popular participation' are now part of the normal language of many development agencies (Adnan et al, 1992; Rahnema, 1992; World Bank, 1994). However, it has become such a fashion that almost everyone says that participation is part of their work. This has created many paradoxes. The term 'participation' has been used to justify the extension of control of the state as well as to build local capacity and self-reliance; it has been used to justify external decisions as well as to devolve power and decision making away from external agencies; it has been used for data collection as well as for interactive analysis.

In conventional soil conservation projects, participation has commonly centred on encouraging local people to sell their labour in return for food, cash or materials. Yet these material incentives create dependencies and give the misleading impression that local people are supportive of externally driven initiatives. This paternalism undermines sustainability goals and produces impacts which rarely persist once the project ceases (Bunch, 1983; Reij, 1988; Kerr, 1994; Pretty and Shah, 1994).

The many ways that development organizations interpret and use the term participation can be resolved into seven clear types. These range from manipulative and passive participation, where people are told what is to happen and act out predetermined roles, to self-mobilization, where people take initiatives largely independent of external institutions (Table 16.4). This typology suggests that the term 'participation' should not be accepted without appropriate clarification. The problem with participation as used in Types 1–4 is that any achievements are likely to have no positive lasting effect on people's lives. The term participation can be used, knowing it will not lead to action. Indeed, some suggest that the manipulation

Table 16.4 *A typology of participation: How people participate in development programmes and projects*

Typology	*Characteristics of each type*
1. Manipulative participation	Participation is simply a pretence, with 'people's' representatives on official boards who are unelected and have no power
2. Passive participation	People participate by being told what has been decided or has already happened. This involves unilateral announcements by an administration or project management without listening to people's responses. The information being shared belongs only to external professionals
3. Participation by consultation	People participate by being consulted or by answering questions. External agents define problems and information-gathering processes, and so control analysis. Such a consultative process does not concede any share in decision making, and professionals are under no obligation to take on board people's views
4. Participation for material incentives	People participate by contributing resources, for example labour, in return for food, cash or other material incentives. Farmers may provide the fields and labour, but are involved in neither experimentation nor the process of learning. It is very common to find this called participation, yet people have no stake in prolonging technologies or practices when the incentives end
5. Functional participation	Participation seen by external agencies as a means to achieve project goals, especially reduced costs. People may participate by forming groups to meet predetermined objectives related to the project. Such involvement may be interactive and involve shared decision making, but tends to arise only after major decisions have already been made by external agents. At worst, local people may still only be coopted to serve external goals
6. Interactive participation	People participate in joint analysis, development of action plans and formation or strengthening of local institutions. Participation is seen as a right, not just the means to achieve project goals. The process involves interdisciplinary methodologies that seek multiple perspectives and make use of systemic and structured learning processes. As groups take control over local decisions and determine how available resources are used, so they have a stake in maintaining structures or practices
7. Self-mobilization	People participate by taking initiatives to change systems independently of external institutions. They develop contacts with external institutions for the resources and technical advice they need, but retain control over how resources are used. Self-mobilization can spread if governments and NGOs provide an enabling framework of support. Such self-initiated mobilization may or may not challenge existing distributions of wealth and power

Source: Pretty, 1995a

that is often central to Types 1–4 means they should be seen as types of non-participation (Hart, 1992; Satterthwaite et al, 1995).

Great care must therefore be taken over both using and interpreting the term participation. It should always be qualified by reference to the type of participation, as most types will threaten rather than support the goals of sustainable agriculture. What is important is to ensure that those using the term participation both clarify their specific application and define better ways of shifting from the more common passive, consultative and incentive-driven participation towards the interactive end of the spectrum.

In recent years, the creative ingenuity of practitioners worldwide has hugely increased the range of participatory methods and approaches in use (see Conway, 1987; KKU, 1987; *PLA (formerly RRA) Notes*, 1988 cont.; Mascarenhas et al, 1991; Chambers, 1992; IDS/IIED, 1994; Pretty et al, 1995). These imply shifts of initiative, responsibility and action to rural people themselves, and result in processes of collective learning leading to collective action. Sustainable soil and water conservation, with all its uncertainties and complexities, cannot be envisaged without all stakeholders being involved in continuing processes of learning and action.

Future Challenges: Towards Land Husbandry

Soil and water conservation practices based on imposed technological interventions have not delivered the environmental or economic benefits they promised. The practice of designing and implementing interventions without involving local people can only succeed with coercion. Such enforced responses may appear technically appropriate, but are commonly rejected by local people when external pressure is removed.

A thorough reassessment of existing soil and water conservation practices is needed, building on the recent experiences of participatory and farmer-oriented programmes that emphasize the broader goals of land husbandry. These experiences signal that changes to soil and water conservation programmes are both possible and positive. The principal impacts have been:

- economic benefits, such as increases in land value and demand for labour, substantial increases in crop and livestock production, and increases in fodder and fuel production, increases in the diversity of crops grown, and improvements in livelihood security through the diversification of livelihood sources;
- social benefits, such as greater self-confidence and sense of cohesion in communities, reduced conflicts over resources, reduced out-migration, attention to the needs of landless groups and new rapport between local people and external professionals;
- environmental benefits, such as recharge of aquifers and increased supply of drinking and irrigation water, reduced soil erosion, salinity, and the use of

fertilizers and pesticides, increased numbers of trees, birds and other wildlife.

Despite the differences in cultural, political and bio-physical contexts, there are important common elements. All emphasize the use of locally adapted resource-conserving technologies that provide immediate returns to farmers, rather than the use of externally derived technologies. All focus on encouraging action by groups or communities at local level, rather than working with individual farmers. All involve supportive government and/or non-government institutions working in partnership with each other and with farmers.

As conditions and knowledge change, so farmers and communities must be encouraged and allowed to change and adapt also. Sustainable soil and water conservation must not impose models or packages. Rather, it should become a process for learning and perpetual novelty.

The challenge now is to identify and encourage the conditions that will foster the further spread of these innovative efforts. Most of these are still only islands of success. This is partly because favourable policy environments are missing. Most agricultural policies still actively discriminate against sustainability. Existing policy frameworks are now one of the principal barriers to the spread of a more sustainable and productive agriculture, and this is where future changes will be essential.

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17

Rethinking Agriculture for New Opportunities

Erick Fernandes, Alice Pell and Norman Uphoff

Over the last 30 years, the creation and exploitation of new genetic potentials of cereal crops, leading to what is called the Green Revolution, has saved hundreds of millions of people around the world from extreme hunger and malnutrition, and tens of millions from starvation. However, these technologies for improving crop yields have not been maintaining their momentum. The rate of yield increase for cereals worldwide – around 2.4 per cent in the 1970s and 2 per cent in the 1980s – was only about 1 per cent in the 1990s. Although the global food production system has performed well in recent decades, will further support of conventional agricultural research and extension programmes increase yields sufficiently to meet anticipated demand?

The next doubling of food production will have to be accomplished with less land per capita and with less water than is available now (Postel, 1996). The gains needed in the productive use of land and water are so great that both genetic improvements and changes in management will be required. The world needs continuing advances on the genetic front; however, food production is more often limited by environmental conditions and resource constraints than by genetic potential. Preoccupation with the methods that brought us the Green Revolution can divert attention from opportunities that can increase food supply without adversely affecting the environment, which are considered in this book.

Given appropriate research, policies, institutions and support, food production could be doubled with the existing genetic bases. Many of the needed advances in food production could be achieved by developing agricultural systems that capitalize more systematically on biological and agroecological dynamics rather than by relying so much on agrochemicals, mechanical and petrochemical energy and genetic modification.[1] This will require, however, some rethinking of what constitutes agriculture.

Although it has been argued that agricultural output will decline if 'modern' agriculture is not promoted to the maximum (e.g. Avery, 1995), 'lowtech'

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methods can be very productive with now-better-understood scientific bases. Where economically justifiable, these methods use available resources more efficiently than do high-input approaches.

The potential of non-mainstream methods cannot be known until agroecological approaches are taken more seriously and evaluated systematically. Gains made through genetic improvement and use of external capital and chemical inputs over the last four decades have been substantial, and the first Green Revolution, despite the shortcomings some critics have pointed to, was one of the major accomplishments of the century.[2] But what will agricultural science do for an encore? While biotechnology holds out many promises, most of its benefits continue to be anticipated more than realized. Access to and widespread distribution of biotechnology's prospective benefits remain uncertain. The widely publicized 'golden rice' is still years from production in farmers' fields.

The challenge facing agriculture worldwide involves more than just achieving higher production, justifiable as that goal has been for previous scientific innovation when serious food deficits were an ominous possibility. Valid ecological and social considerations now make it imperative that further advances be environmentally friendly as well as economically sustainable and socially equitable. Also, more than increased food supply is needed; we should aim to ensure balanced and adequate supplies of nutrients that people can afford. In particular, adverse environmental and health externalities that result from modern agricultural methods – soil erosion, chemical hazards, soil and water pollution – are things that nobody would like to see increased, let alone doubled, as we seek to double the production of food.

Should resources for agricultural research be devoted, for example, to developing genetically engineered rice with high levels of vitamin A, assuming that cereal grain monoculture will continue to predominate? Or should we strive to incorporate nitrogen-fixing and nutrient-rich legumes and livestock into farming systems to better meet people's nutritional requirements with diversified diets – while simultaneously maintaining soil fertility? Such questions need to be addressed.

The next Green Revolution will depend at least in part on enlarging upon and diversifying the ideas that have guided past development efforts. The paradigms that presently organize and direct agricultural research and extension have been helpful for planning activities and producing theoretical explanations. But they have also created certain blind spots. The task of meeting world food needs will be more difficult if our vision of what is possible is limited by constraining conceptions of how best to raise agricultural output in effective, efficient and sustainable ways.

Agriculture as Field-culture: An Etymological Perspective

The very concept of agriculture as it has been understood and practised in the West has been shaped by its semantic origins, coming from the Latin word ager, 'field'. Agriculture is mostly understood as the growing of plants in fields. (Similarly, in

South Asia, most words for agriculture derive from the Sanskrit word for plough, *krsi*, so that agriculture in that region is characterized as 'plough work'.) Such a conceptualization, however tacit, makes the raising of livestock, fish, trees and other activities less central to the agricultural enterprise, except where cattle or oxen are necessary for ploughing, or where monocrop tree plantations substitute for fields. The full range and richness of the agricultural enterprise has not been well captured in the word that we use to refer to it.

Etymologically, it is not clear where livestock, fish, insects, microbes and trees fit in. Few sustainable farming systems exist that do not include several of these groups in addition to plants. But most often, those who work on other flora or on fauna have been accorded marginal status within agricultural ministries, or been assigned to separate ministries, leaving crop and soil specialists in charge of the agricultural sector.

Fishery departments are invariably marginal if located within an agricultural ministry, even though aquaculture integrated within farming systems has great potential. Indeed, until 'agroforestry' was discovered (King, 1968; Bene et al, 1977) and the International Centre for Research in Agroforestry (ICRAF) was established, there was little concern with trees as part of agriculture, except in large-scale plantations where tree crops were commercially profitable. Otherwise, trees got respect and attention only if looked after by a separate ministry that was more concerned with forests or plantations than with farms.

Although *agroforestry* may sound like a kind of forest management, it is a comprehensive land-use management strategy that includes a range of woody perennials (particularly trees but also shrubs) in spatial and temporal associations with non-woody perennials, grasses and annual crops, together with a variety of animals, including cattle, sheep, goats, pigs, chickens, guinea pigs, fish and even bees (Lundgren and Raintree, 1982). While some agroforestry practices are extensive – for example, most agrosilvopastoral systems – these practices generally contribute to intensified production that is agroecologically sound and maintains soil fertility (Fernandes and Matos, 1995). Fortunately, the integration of perennial plants into otherwise annual farming systems is increasingly recognized as a mainstream opportunity to increase per-hectare output in future decades.

A bias in favour of fields means that horticulture gets somewhat marginalized in most institutions dealing with agriculture, including universities. Gardens and orchards, being smaller, have lower status than fields, even if they produce several times more value per unit of land when intensively managed. Horticulture is devalued in part also because its produce is mostly perishable and hard to denominate. Heads of cabbage and baskets of apples are hard to compare with bags of rice or tons of wheat, their nutritional value notwithstanding. Historically, governments have gained more wealth and security from grains because these could be stored (or seized) more easily than fruits and vegetables.

Farming systems of most rural households around the world depend crucially upon livestock and poultry, large and/or small, together with home gardens and orchards and often with fish ponds and hedgerows. Efforts to improve single components of farming systems are likely to produce limited results unless the interdependence of land use, labour supply and seasonal activities for all of these farm enterprises is acknowledged.[3] In many areas of Asia, acceptance of the short-stalked, high-yielding cereal varieties that made the Green Revolution was low, for example, because the quantity and quality of the fodder produced by the new varieties was insufficient to meet livestock requirements. The goal of plant breeders had been to increase grain yield without considering forage needs. Farmers were willing to accept lower yields of grain in order to be able to feed their animals, which provided them with the manure they needed to maintain soil fertility and the traction required for tilling their land.

An argument sometimes made against livestock production is that animals are inherently wasteful; more calories can be produced per hectare from plants than from animals. If animals are fed on forages and by-products, however, rather than competing with humans for edible grain, such 'wastefulness' can be beneficial. In extensive and semi-extensive systems, animals that range freely during the day harvest plant nutrients from non-arable areas; at night when they are penned, most of these nutrients are deposited in their enclosure, later to be distributed as manure onto cropland. In parts of West Africa, pastoralists often negotiate grazing contracts with crop-growing neighbours. Pastoralists are encouraged to graze their cattle on fields with crop residues because the cattle deposit manure: their owners may even receive additional compensation for this service. If animals were in fact highly efficient in their conversion of harvested nutrients, there would be less transfer of nutrients from rangelands to croplands.

When green and animal manures are judiciously used in combination, nutrient availability can be nicely synchronized to meet plant demands. Manure is an important product of livestock raising. In sub-Saharan Africa, 25 per cent of agricultural domestic product comes from livestock even without considering manure or traction; when these are considered, this figure rises to 35 per cent (Winrock International, 1992). The quality and quantity of manure produced depends on what the animal consumes; in Java where 'cut and carry' tree-based fodder systems are common, animals are given extra feed to improve the quality of their manure (Somda et al, 1970; Tanner et al, 1995). Thus, animal production can be beneficial in ecological as well as human nutritional terms.

An additional consideration obscured by a preoccupation with fields is that common property resources for grazing and for forest products are an essential part of many households' economic operations (Berkes, 1989; Jodha, 1992).

Common lands are often the sites from which grazing livestock harvest nutrients that are brought back to the farm at night. As these areas are not fields, however, and do not belong to any specific user, evaluating their contributions to production is admittedly difficult. This is not, however, sufficient reason to overlook their role and potential, leaving their productivity to languish.[4] Privatization of these commons, often advised, removes the flexibility people need to withstand drought in dry regions. Farming systems improvement should encompass all the area and resources available to farmers and pastoralists.

Developing an adequate knowledge base for more productive and sustainable agriculture should start with explicit acknowledgement that agriculture involves much more than fields and field crops. To be sure, fields are commonly the main component of most farm production strategies. *Staple foods* are, after all, what their name implies – essential for food security. The world in general needs more, rather than less, of them, especially for the 800 million people who are currently undernourished. But other sources of calories are also important – potatoes, cassava, yams, sorghum, millet, sweet potatoes, taro, fish, meat, milk and so on – and these have been given much less support than rice, wheat and maize.[5] Calories, while necessary for survival, are not sufficient for human health. To achieve balanced diets, including essential micronutrients, the whole complex of flora and fauna that rural households manage to achieve food security and maintain their living standards should be better understood and utilized.

Not only should fixation on individual crops be avoided, but a broader understanding of the biophysical unit for agriculture is needed. A narrow focus on fields is giving way to a broader focus on *landscapes* and/or *watersheds*, within which fields function as interdependent units, especially as we gain a better agro-ecological understanding of agriculture (Carrol et al, 1990; Altieri, 1995; Conway, 1997).

Assumptions Associated with Field-centred Agriculture

Several limitations arise from this long-standing concept of agriculture. In different ways, each works against strategies for intensified and sustainable agricultural development that use the full set of local resources most productively.

The time dimension of agriculture: A cyclical view

In lore and literature, agriculture is described and celebrated as 'the cycle of the seasons'. How is agriculture practised with its field-based definition? By ploughing, planting, weeding, protecting and finally harvesting. Farmers then wait until the next growing season to plough, plant, weed, protect and harvest again, and wait once more for the next planting time. Planting defines agriculture in our minds as does the activity of harvesting. Yet if one looks beyond this standardized seasonal conception of agriculture, one finds trees that keep their leaves year-round, sheep that lamb twice a year, and microbes that continuously decompose soil organic matter with generation intervals measured in hours or minutes. These different time frames all affect agricultural performance.

Fixation on an annual cycle of agriculture has arisen from its practice in temperate climates, where most modern scientific advances have been made. There, summer and winter seasons are the central fact of agricultural life. The year-round agriculture of tropical zones seems somehow irregular, almost unnatural, since it lacks periodic cultivation. This view is reflected in reports from early colonial administrators in tropical countries who regarded indigenous populations as 'lazy' because they did not work hard to produce their sustenance. There was no annual cycle of ploughing, planting and so on, which counterparts in colder climates had to maintain. People who harvested what they had not planted, or had not planted recently, were not regarded as 'real agriculturalists' by people from temperate zones.

There is seasonality in tropical regions, to be sure. The contrast between wet and dry seasons can be as stark as that between summer and winter. But with agriculture seen primarily as a matter of *cultivation*, annual crops get more attention and status than perennials. The latter have very important roles to play, however, particularly if one is concerned with the sustainability of agriculture. Their growth usually does not disturb or tax the soil as much, or as often, as does annual cropping. The latter invests in myriad biological 'factories' that produce food or fibre and then demolishes them at the end of the season. On the other hand, trees, vines or crops that ratoon keep all or most of that biological factory intact from year to year.

Since, usually, very little biomass is discarded in the farming systems operated by poorer farm families – it is used for fodder, fuel, mulch or other purposes – our point here is directed to research and extension priorities rather than to farmers. The latter have long known that combining a variety of perennials with annuals, animals and horticultural crops creates opportunities for more total output from given areas of land during the year, and with less pressure on soil resources; energy and nutrient flows are more efficient, and adverse pest and environmental impacts can be reduced by growing perennials rather than annuals.[6] Especially if the sustainability of agricultural production is an objective, giving perennials a larger role in agriculture makes sense.

Within agriculture understood in annualist terms, fallows are periods of rest and recuperation for the soil, a kind of gap in the cropping calendar. Many farmers, however, have thought of fallows differently, managing them so that they are more productive than land that is simply left alone. 'Managed fallows' are not an oxymoron but rather a source of supplementary income, providing fodder, fruit or other benefits while enriching the soil when leguminous species or plants otherwise considered to be weeds are allowed or encouraged to grow.[7] Cropping cycles are best looked at in terms of how soil fertility can be continuously enhanced while utilizing a wide variety of plant and animal species – a strategy described as 'permaculture' by Mollison (1990) – looking beyond crops that are planted periodically.

Spatial dimensions of agriculture: Thinking in terms of soil volume instead of surface

Agriculture has been defined and limited by a mental construction of agricultural space in much the same way that it has been stereotyped in terms of annual cycles.

While farmers have long appreciated that agriculture is an enterprise best conducted in three dimensions, most agronomic and economic assessments consider agriculture essentially in *two dimensions*, as an enterprise carried out on a plane. The practice of agriculture is epitomized by ploughing, which breaks the surface of the soil in order to plant seeds and grow crops. This strategy suffices so long as the soil is deep, fertile and well supplied with water. But agriculture can be made more productive by conceiving and treating soil in *three-dimensional* terms, as volume, doing more than just breaking its surface and working it two-dimensionally.

Indeed, working the soil is a better term for agriculture than ploughing it, since working encompasses many functions.[8] This concept includes incorporating organic matter of various sorts into the soil and altering soil topography to capture and hold water, or to drain it. Getting crop residues and animal manures into the soil can promote greater synchrony between nutrient release from those residues and crop nutrient demand; soil organic matter promotes better water infiltration and retention at the same time that it creates better habitats for soil microflora and for micro- and macrofauna. In many traditional farming systems around the world, one finds soil being mounded into raised beds and even raised fields; terraces are constructed to retain and improve the soil and to make watering it easier, and drains are often installed. Soil-working activities are intended not just to exploit the soil's fertility but to improve it.

Alternately, in some farming systems one finds no ploughing, just the planting of seeds in undisturbed soil. This might be considered one-dimensional agriculture with activities concentrated on points rather than a surface, leaving the volume of soil beneath intact to nurture macro- and microbiological communities. To be sure, two-dimensional thinking accomplishes some important activities such as weed control and breaking the soil crust, but disturbances of the soil contribute to major erosional losses. Weeds can be controlled by other means than ploughing, and 'no-till agriculture' is now widely accepted as a modern practice, as noted below.

In the coming decades, efforts to raise yields per hectare should not take the quality and durability of soil for granted, as the health and fertility of the soil are critical for productive and sustainable agriculture. Soil should be understood and managed in terms of its *volume* rather than its *surface*. Raising output sustainably will require more than working chemical fertilizers into the top horizon. Thinking of soil three-dimensionally should be part of any strategy for sustainable agricultural intensification.

Monoculture as 'real' agriculture

The standard view of agriculture as limited in time and space favours monocropping for achieving control and efficiency in production. Applying inputs is made easier with monoculture, whether calculating fertilizer applications or using mechanical power for weeding. But the conclusion that this is always the most productive way to use land is mistaken. This production method can raise the economic returns to labour or to capital, but it does not necessarily increase the returns to land. The latter resource will become ever more important in coming decades as the availability of arable land per capita declines.

Polyculture systems employing a combination or even a multitude of plants commonly have higher total yields per hectare, absorbing and generally requiring higher inputs of labour and nutrients. Where labour is relatively abundant and land is relatively scarce, this can be an efficient and economic system of resource use. The advantage of monocropping is that it makes mechanization, substituting capital for labour, more effective.[9] Only where mechanical power can bring into cultivation land that manual power cannot is greater physical production likely to result from mechanization. This generally makes agriculture more extensive than intensive.

Even when population is high in relation to arable area, it can be difficult to attract or retain labour to work in farm operations. Much of the impetus for farm mechanization has come from labour scarcities in the more economically advanced countries. When tractors and other machines have been introduced into developing countries with the mistaken idea that this will raise production, they have done more to displace labour than to make land more productive. Tractorization can raise profits for those who have greater access to land and capital, but it seldom leads to higher output per unit of land than using hand labour and animal traction, other things being equal.[10] In contrast to tractors, animals used for traction reproduce themselves, pay returns on the farmer's investment, and provide food, fuel and fertilizer at the same time. Since capital is so often subsidized by government policies, one should not consider the private profitability of using tractors and other capital inputs as a sole or sufficient justification for their use without analysing the full range of social costs and benefits.[11]

Because polyculture is less amenable to mechanization, it requires an adequate and reasonably skilled supply of labour. Many of the practices we discuss here are relatively labour-demanding, using human energy and skill instead of capital and chemicals to get more production from limited land resources. To the extent that investments of labour are made more productive by agroecological innovations, they can be better remunerated and lead to improvements in the agricultural sector and the rest of the economy.

It is widely believed, with more emotion than calculation, that clean-ploughed fields, sown uniformly in a single crop, planted neatly in rows with all extraneous plants removed, is the best kind of agriculture. Mulch makes fields look messy, and crop mixtures look chaotic rather than productive. But this assessment is more a matter of aesthetics than of science. Yields, yield stability and nutritional quality per unit of land from polyculture, although harder to measure, are usually greater than with monoculture.[12] Furthermore, keeping soils covered protects them against erosion.

Polycropping supported by a strategy of managing and recycling organic inputs offers many advantages and can raise yields with equivalent inputs. When maize and soybeans are intercropped, for example, there is about a 15 per cent gain in production that cannot be explained simply by the inputs applied, an increase reflecting synergy within the crops' growing environments (Vandermeer, 1989). Plant–animal intercropping yields comparable benefits. There are many situations, determined more by economic than by agronomic considerations, where monoculture will be a preferable strategy. But its superiority should not be assumed without proof, as happens now.

Mechanical conceptions of agriculture

Monocropping implicitly regards agriculture as a mechanical process, with inputs being converted into outputs by some fixed formula, whereas polycropping recognizes the inherently biological nature of agriculture. The relation posited between inputs and outputs is different for mechanical and biological paradigms. In the first, the ratio of outputs to inputs is predictable and proportional, fixed and usually linear. In the realm of nature, on the other hand, relationships are less predictable and seldom proportional. Large investments of inputs can come to nought, while under favourable conditions and with good management, modest inputs have many-times-larger effects.

Until something like the perpetual motion machine is invented, such disproportionality is not possible with mechanical phenomena, which depend on continuous inputs for their operation. Biological processes, on the other hand, can be self-sustaining and can adapt and evolve unassisted. Moreover, biological *inputs* can reproduce themselves. How one regards and utilizes inputs thus differs in subtle but important ways according to whether they are understood within a mechanical framework or in a biological context.

One area where 'modern' agriculture has rediscovered the advantages of biology is with so-called minimum tillage or no-till systems, now given the positive appellation 'conservation tillage' (Avery and Avery, 1996). Twenty years ago this was considered atavistic agriculture, harking back to the dibble stick in a modern era when heavy tractors and field machinery should be used to plough, plant, weed and harvest 'clean' fields. Yet no-till agriculture has now become state-of-the-art in many areas of the US. Mechanical corn harvesters are designed to chop up plant stalks, leaves, husks and cobs to return this biomass to the land in biodegradable form to preserve soil fertility. In addition to recycling nutrients, conservation tillage protects the soil's surface and reduces wind and water erosion. The main limitation with little or no tillage is that weeds can become more of a problem unless farmers can afford chemical herbicides or use hand labour. (This new/old technology has become popular with businesses that sell herbicides to control weeds when there is no ploughing).

Innovative practices like the use of mulches, cover crops and green and animal manures, which were until recently largely ignored in 'modern' agriculture, can solve the problem of weeds. These techniques capitalize on the large dividends that nutrient recycling can pay because of the multiplicative dynamics of biological processes. Whereas mechanical advantage is a well-accepted principle in physics and engineering, agricultural science should capitalize on the analogous and even more powerful principle of *biological advantage*.

Four Equations in Need of Revision

Efforts to raise agricultural productivity have been guided for many decades by four presumptions. These have produced some impressive results, so our objection is not that they are wrong. Rather, they have become too dominant in our thinking, with too hegemonic an influence on policy and practice. It has been taken for granted that they represent superior ways to boost production. This thinking can be stated in four tacit equations that have shaped contemporary agricultural research, extension and investment.

1. Control of pests and diseases = application of pesticides or other agrochemicals.
2. Overcoming soil fertility constraints = application of chemical fertilizers.
3. Solving water problems = construction of irrigation systems.
4. Raising productivity beyond these three methods = genetic modification.

Equating certain kinds of solutions with broad categories of problems limits the search for other methods to solve those problems, even when alternative practices might have a lower cost and be more beneficial in environmental and social terms. More progress in agriculture will be made if the above propositions are broadened. Fortunately, there is a good precedent in the way that the first equation has been substantially modified over the past 15 years.

Crops and animals can be protected by non-chemical means

The modern-input paradigm for raising production has been most directly challenged with regard to pest and disease control through what is called *integrated pest management* (IPM). Adverse effects on human health as well as on the environment caused some scientists to explore ways to produce crops and animals with little and even no use of chemicals. Biological controls as well as alternative crop management practices have often turned out to be more cost-effective, and sometimes simply more effective. The chemical-based strategy of 'zero tolerance' for pests and diseases, rather than being a solution, exacerbates the problem, killing beneficial insects that are predators of crop pests. The widespread use of agrochemicals, particularly broad-spectrum ones, has had the consequence of making pest attacks worse.[13] Routine use of antibiotics to treat diseases and promote the growth of livestock has, unfortunately, increased the antibiotic resistance of pathogens that can infect humans and/or animals.

An IPM strategy does not preclude the use of chemicals. But the first lines of defence against pests and diseases are biological, trying to utilize the defensive and recuperative powers of plants and animals as well as the activity of beneficial and predator insects to farmers' advantage.[14] The Indonesian IPM programme, for example, taught farmers that spiders, previously viewed with antagonism, should be protected and preserved. Demonstrations showed that rice beyond a certain stage can sustain extensive leaf damage from insects, as much as 25 per cent, without depressing effects on yield, and even possibly some gain. When sheep in Australia and South Africa were fed leguminous forages containing tannins as part of their diets, their internal parasite loads were reduced, reducing expenditures on antihelmintic medicines and providing an alternative treatment when antihelmintic resistance is a problem (Kahn and Diaz-Hernandez, 2000). The presumptions of modern agricultural science regarding chemical means for pest and disease control have been broadly challenged, with such means being increasingly reduced and avoided where possible.

Soil fertility can be enhanced, often more effectively, by non-chemical means

The most broadly successful component of modern agriculture has been the introduction and use of inorganic fertilizers to supply soil nutrients, particularly nitrogen, phosphorous and potassium, where these were lacking. But this success has led many policy makers and some scientists to equate soil fertility improvement with the application of fertilizers when, in fact, fertility depends on many additional factors. Indeed, the misuse or overuse of chemical fertilizer results in adverse effects on yield by negatively affecting the physical and biological properties of soil. The advantage of inorganic fertilizers is that they are easier to apply, often cheap (if subsidized) and have more predictable nutrient content. Also, organic nutrients are sometimes simply not available in sufficient supply.

When inorganic fertilizers are added to soils that possess good physical structure, with adequate soil organic matter and sufficient cation-exchange capacity, they can produce impressive improvements in yield. Where soils are acidic (low pH) and the nutrients needed for plants are in short supply, the application of appropriate amounts of lime (calcium carbonate) along with inorganic fertilizers can result in spectacular crop yield increases and can greatly improve farmer income. But in many circumstances, especially in the tropics, soils are not so well structured or well endowed. Then, inorganic fertilizers, especially if used in conjunction with tractors that compact the soil, can lead to changes in soil physics and biology that are counterproductive and diminish, sometimes sharply, the returns from adding chemical nutrients.

We have suggested to dozens of soil scientists in the US and overseas that probably 60–70 per cent of soil research over the past 50 years worldwide has focused on soil chemistry and about 20–30 per cent on soil physics. This means that less than 10 per cent of soil research has been devoted to improving our understanding of its biology. This estimate has not been challenged by agronomists to date. Why such preoccupation with soil chemistry? It is the easiest kind of soil deficiency to study, giving quick, precise and replicable results, which point to simple remedies. The results of soil chemistry analyses are easy to interpret; by adding certain amounts and combinations of fertilizer nutrients, one can expect predictable increments to production. Moreover, such research gets funding easily, given the interests of fertilizer producers in such knowledge.

Yet even brief consideration of these three domains affecting soil fertility suggests that the amount of effort going into each, even if not necessarily equal, should be closer to parity. Any national research programme that deliberately allocated its scientific resources in the above disproportions would be considered misguided. Microbial activity is essential for nutrient availability and uptake. When one walks on ground that has been converted by leguminous species, compost, mulch or manures from something resembling concrete into absorbent, friable soil underfoot with good tilth, the contribution of soil microbiology is self-evident. But studying biological processes is more difficult than assessing differences in soil structure, and many times more difficult than measuring the chemical composition of soil samples.

Similarly, plant scientists with whom we have spoken have agreed that 90 per cent or more of their research effort over the past 50 years has been devoted to those parts of plants that are above ground, and less than 10 per cent to what is below ground. Indeed, plant scientists usually suggest that less than 5 per cent of their research has investigated sub-surface processes and dynamics. Yet any assessment of how plants grow and thrive suggests that a more balanced distribution of effort is desirable, with much more attention paid to the growth and functions of roots than in the past. However, just as it has been easier to study the chemistry of soil, it has been easier to analyse leaves and stalks than to probe the underground mechanisms of roots for uptake and transport of nutrients and water. Changing the soil's temperature by just a few degrees can alter significantly the microbial populations underground, for example, which makes such research difficult to replicate and validate.

Modern agricultural research's focus on soil chemistry and above-ground portions of plants has led to solutions that favour chemical and mechanical means. The belief that chemical fertilizers are the best way to deal with soil fertility limitations has arisen from – and has reinforced – the image of agriculture as a kind of industrial enterprise, where producing desired outputs is mostly a matter of investing certain kinds and amounts of inputs. Consequently, viewing agriculture more as a biological than as a mechanical process attaches greater value to the use of organic inputs. In recent years there has been a major increase in the application of biologically based technologies, such as vermiculture (raising worms) to enhance soil fertility and ameliorate the negative effects of industrial and agricultural wastes on soil (Appelhof et al, 1996; Acharya, 1997).

As in most things, combinations of factors are more likely to approach the optimum than one factor by itself. It is well known that for plants to utilize chemical fertilizer effectively, the soil in their root zone must have substantial capacity to retain and exchange nutrient cations, and that exchange capacity is considerably enhanced as soil organic matter content increases. Research shows the benefits of utilizing organic means to maintain soil fertility and also of adding some inorganic nutrients in combination with organic inputs to get the best results.[15]

Adding appropriate amounts and combinations of chemical nutrients can increase both plant productivity and the amount of crop residues (shoots and roots) that become available to increase and maintain soil organic matter. Augmenting organic matter is especially necessary in tropical soils, which, due to climatic and edaphic conditions, are more likely to need maintenance and restoration of organic material and nutrients. The bottom line is that chemical fertilizers by themselves are no substitute for incorporation of soil organic matter. Ideally both will be used in synergistic ways.[16]

Irrigation is not the only way to deal with water limitations

A mechanistic conception of agriculture reinforces the millennia-old fixation on irrigation as the best if not the only means of providing water for plants in water-scarce environments. In many places, given hydrological cycles and opportunities, irrigation is certainly necessary for the practice of agriculture. But its success over several thousand years has led people to look to this technology as the universal solution to water scarcity problems. When crops need water, the first thought is how to provide irrigation from surface or groundwater sources.

But there are other ways to meet crop requirements besides capturing water in a reservoir, by river diversion or by pumping it from some body of water above or below ground, and then conveying it through canals and other structures to deliver it to particular fields, in amounts and at times when it is needed.[17] In much the same way that assuming soil fertility problems are best solved by fertilizer applications, seeing water shortages as best handled by irrigation has made water harvesting and conservation almost lost arts. When farmers in semi-arid Burkina Faso, assisted by OXFAM, demonstrated that they could grow much better millet crops simply by placing rows of stones across their fields, to slow water runoff and store it in the soil, this was seen as a remarkable technology (Harrison, 1987, pp165–170); numerous case studies with similar results have been documented in Reij et al (1996). Such practices should become part of the repertoire of soil and water management practices that farmers can adopt to utilize available rainfall most advantageously. Using mulch to capture water and slow evaporation is another simple method.

Measures to conserve and utilize water, like planting crops in certain rotations or seeding a new crop in a standing one to capitalize on residual moisture, should not be seen as something novel but rather as something normal, making the best use of water in combination with soil. Methods including collecting and storing water in small catchment dams, large clay jars or simply in porous soils should be experimented with to determine which designs can provide enough water to crops and animals (and for human uses) to justify the expenditure of labour and capital and sometimes land. Small catchment ponds are becoming more attractive and feasible options, providing water supplies in situ. We should also understand better how land preparation practices affect water retention and utilization.[18]

Irrigation will surely remain a major means for solving water problems, and we should be learning how to use scarce irrigation water more efficiently and effectively through social organization (Uphoff, 1986; 1996). But irrigation is not the only means to ensure that growing plants and animals have the water they need. Water scarcity will surely increase for agriculture around the world, so all possible means to acquire and conserve water need to be considered.

Genetic manipulation is not always necessary to raise production significantly

The modern approach to agricultural improvement has stressed better plant and animal breeding, especially since the advent and success of the Green Revolution. Without denying the value of such efforts, or that there will be some future benefits from biotechnology, we think more attention should be paid to cultural practices, to soil preparation and management, to the use of organic inputs, to more productive cropping patterns and systems, and to species that have previously been overlooked or underutilized.

A good example is the system of rice intensification (SRI) developed in Madagascar which can boost yields from any variety of rice by 100–200 per cent or more by changing management practices and without requiring any use of purchased inputs. There are other examples of major yield increase potentials with staple crops. In the 1970s, a programme in Guatemala was able to help farmers raise their maize and bean yields from 400–600kg/ha to about 2400kg in just seven years, at a cost of about US$50 per household. Farmers who had become acquainted with experimentation and evaluation methods proceeded to double yields once more on their own after external assistance was withdrawn. Very poor farmers working with an NGO in the high Andean regions have found that they could double or triple their yields of potatoes and barley by using lupine, a leguminous plant, as a green manure to add nitrogen to the very poor mountain soils and increase soil organic matter. This method, like SRI in Madagascar, works with whatever varieties farmers are already planting and uses organic rather than chemical inputs from outside the community. Leguminous fallows can raise maize yields in southern Africa by two to four times.

The Mukibat technique, named after the farmer who devised it in Indonesia almost 50 years ago, can increase the yield of cassava by five times or more. It involves grafting cassava tubers onto the root of a wild rubber tree of the same genus as cassava, which gives the growing tubers more access to sunlight and nutrients (Foresta et al, 1994). That this technology has aroused so little scientific attention, and was not reported in the literature until more than 20 years after it was devised (Bruijn and Dharmaputra, 1974), may reflect the indifference among most researchers towards cassava, a low-status staple crop on which hundreds of millions of people depend for much of their sustenance. Or perhaps it reflects a lack of interest in innovations that do not come from the scientific community.

Smallholding farmers around the world at present are probably exploiting less than 50 per cent of the existing genetic potential of various crops due to less than optimal management. In many cases this is because the returns to labour are not high enough to justify intensification, but often it is a matter of not knowing how to capitalize on synergies that could raise these returns. Reducing the yield variability of traditional varieties and taking fuller advantage of their genetic potential through nutrient cycling and better soil and water management within complex farming systems could, we think, be a cost-effective strategy that complements longer-run and higher-cost biotechnological efforts being undertaken to produce new and better varieties. Increased production of other food sources, including fish culture, small animals and various indigenous plants, can augment in non-competing ways whatever nutrients are provided by staples.

Even if these alternative methods by themselves cannot achieve a doubling of world food production, they could contribute substantially to this, making up the difference that is unlikely to be produced by more modern means that are heavily dependent on inputs of energy, chemicals and water. Capitalizing on 'non-modern' opportunities will require reorientation of socioeconomic as well as biophysical thinking. It necessitates looking beyond the farm and its fields, and beyond particular crop cultivars, animal species and cultivation practices, to institutions and policies.[19]

Utilizing these Productive Opportunities

Doing 'more of the same' in either the so-called modern or traditional sectors of agriculture is not likely to be sufficient for meeting food needs in the decades ahead. Researchers, extensionists and policy makers who wish to assist households around the world to become more food-secure, healthy and well-off need to consider how to make broadly based improvements in output through evolving systems that are more intensive and more complex. These will resemble but improve upon present practices that are not fully or sustainably utilizing soil, biological and other resources.

Traditional farmers are for the most part quite resource-constrained. The technologies offered by extension services were usually developed for larger, simpler production systems that are not appropriate for the kinds of systems that the majority of farmers in the world are managing. There are wide variations in productivity within and across farming communities, with some producers tapping production potentials better than others. We look towards 'hybrid' strategies to raise production, combining the best of farmers' current practices with insights derivable from modern science to tap the power of plant and animal germplasm nurtured under optimal conditions.

There is no reason to believe that the elements of 'modern' agriculture are wrong, but neither is there a warrant to consider them (yet) complete. They offer many advantages of productivity and profit for large numbers of agricultural producers – but not for all of them, and maybe not even for a majority of farming households around the world today. Our analysis here calls into question the presumption, whether it is argued or assumed, that mainstream approaches are the best or the only way to advance agriculture in the future. For the sake of productivity and sustainability, it will be advisable to 'backcross' some of the modern varieties of agriculture, which are most suitable for advantaged producers and regions, with often more traditional methods so as to develop a more robust 'hybrid' agriculture, one that can better meet the world's needs for food, health, employment and security in this century.

Notes

1 This is not a statement in opposition to research on genetic modification, a controversial subject these days. Transgenic research has some potentially valuable, legitimate and safe uses and we would not want to see it curtailed – though more oversight and regulation and a different international property rights regime would make this enterprise more defensible and beneficial. Improvements in pest- and drought-resistance, for example, if achieved through advanced technology, could be great benefits, particularly for the poor. Our focus on opportunities to raise production through different, more intensive management practices aims at a diversified strategy of agricultural development, one which will include work on genetic improvements.

2 'Had the cereal yields of 1961 still prevailed in 1992, China would have needed to increase its cultivated cereal area more than three-fold and India about two-fold, to equal their 1992 harvests' (Borlaug and Dowswell, 1994).

3 One of the pre-eminent agricultural development projects in the 1960s and 1970s, Plan Puebla in Mexico, was set up to benefit rural smallholder households by increasing their production of maize under rainfed conditions. Maize was considered their main crop. Yet a survey in the Puebla area showed that animal production provided 28 per cent of households' income, more than the 21 per cent that came from maize and almost as much as from the sale of all crops, 30 per cent. In addition, 40 per cent of household income came from off-farm employment (Diaz Cisneros et al, 1997, p123). The project made little progress with small farmers until it sought to improve production of beans along with maize, as these crops, when grown together, produced more than maize grown by itself and also contributed more to family nutrition. Farmers' cooperation also increased when other lines of production were assisted by the project. A more recent survey of 206 households selected randomly in four villages in the northern Philippines found that livestock contributed almost as much to household incomes (90 per cent as much) as did their rice production (Lund and Fafchamps, 1997).

4 In a watershed development programme in the Indian state of Rajasthan, where a participatory approach to technology development was taken that aimed to capitalize on local knowledge, fodder production on rainfed common lands was increased eight- to ten-fold with corresponding improvements in soil conservation (Krishna, 1997, pp261–262). While such areas usually face serious physical constraints on increased production because they have been so neglected by researchers and extension personnel, they often offer substantial opportunities, previously ignored, for raising output.

5 This is discussed by Chambers (1997, especially p47). While rice, wheat and maize have received the lion's share of research funding, at least four of the international agricultural research centres in the CGIAR system have some of these other staple crops as a central part of their mandates. There are also centres now working on animals, agroforestry and aquaculture, though the centre on horticulture has yet to become part of the system (for political reasons). The centres responsible for working on rice (International Rice Research Institute – IRRI) and wheat and maize (International Centre for the Improvement of Wheat and Maize – CIMMYT) are increasingly undertaking research that relates these staples to the growing of other crops.

6 As with most generalizations, this has some exceptions. Some perennial crops make heavy demands on soil nutrients, and others such as pineapples can require heavy agrochemical applications. On the general value of perennials in cropping systems, see Piper (1994) and Piper and Kulakow (1994).

7 Managed fallows have been largely ignored in the existing agricultural literature. To remedy this lack, a South-East Asian regional workshop on intensification of farming systems was held in Bogor, Indonesia, in June 1997, with over 80 papers prepared for this collaborative effort of ICRAF, CIIFAD, the International Development Research Centre of Canada and the Ford Foundation. Documentation of these resource management systems, mostly developed by farmers, is published in Cairns (2000).

8 The German and Dutch words for agriculture, Landbau and Landbouw, are more congenial to a three-dimensional conception of agriculture as they mean land-building.

9 'Mechanization' as used here refers to tractorization. Other forms of mechanization such as water pumps can be very valuable for increasing production, but they are not necessarily linked to monocropping in the way that tractorization is.

10 Those who can afford tractors usually own the best-quality land, making their practice of agriculture appear better.

11 When the labour power available for agricultural production is a constraint in some countries, this often reflects the fact that the low prices paid for agricultural commodities are keeping rural wage rates correspondingly low, influenced by urban-biased national policies and/or agricultural production subsidies in industrialized countries. National policies in developing countries have generally favoured urban consumers over rural producers, leading to low prices for food. Low food prices also reflect the extent of poverty, which depresses the purchasing power of the poor who have need for more food but do not have the means (effective demand) with which to acquire it. In such situations, low wages and low labour productivity for agriculture do not reflect either a true equilibrium or an efficient use of resources in terms of meeting human needs.

12 See Steiner (1982). That monocrop yields, being single, are easier to measure has contributed to the popularity of monocropping as a subject for agricultural research and extension. More effort is required to assess polycropping precisely. In the 1980s a world census of agriculture by the UN FAO specifically ignored all crop mixtures, deciding to record crops only as monocultures (Chambers, 1997, p95).

13 This has been seen and documented most dramatically in Indonesia, where an IPM programme started with FAO assistance showed that rice yields would not decline, and in some instances increased, when use of chemicals was drastically cut back (more than 50 per cent), and in some cases terminated where cultural practices were changed. The key was giving farmers effective hands-on training in agroecosystem management, so that they began to diagnose problems themselves and experiment with solutions, developing alternatives to chemical dependence (Oka, 1997). Widespread use of chemicals had increased the problem of pest attacks on rice, inducing build-up of pesticide resistance in pest populations at the same time that it reduced the population of spiders and other 'beneficials' that prey on pests.

14 Recent research on rice IPM has found that maintaining the populations of 'neutral' insects in rice paddies, insects that are neither pests nor beneficials, is important. Their presence can sustain the populations of beneficials when pests have been eliminated, keeping these populations vigorous

and available to deal with any new increases in pest populations. Keeping sufficient organic matter in the soil to support populations of neutrals is becoming part of an IPM strategy (personal communication, Peter Kenmore, during Bellagio conference).

15 See Fernandes et al (1997). On infertile acid soils, farmers often need to use certain chemical nutrients such as phosphorus and calcium to prime biological processes such as nutrient recycling and nitrogen fixation. Research in Costa Rica found that when cultivating beans, mulches of organic matter prevent phosphorous fertilizer from becoming bound to aluminium and other ions in the acid soil, making it more available for plant nutrition. Phosphorus applied in conjunction with organic material produced as good or better yields as when three times as much phosphorus was applied directly to the soil (Schlather, 1998).

16 There is research indicating that the application of inorganic nitrogen fertilizer suppresses potentials for biological nitrogen fixation by reducing micro-organisms' production of the enzyme nitrogenase which enables soil microbes to transform nitrogen from the atmosphere into forms usable by the roots (Van Berkum and Sloger, 1983). This suggests that naturally occurring nitrogen can be made unavailable by the application of nitrogen fertilizers, but it does not negate the point that organic and inorganic sources of nutrients are best managed in a complementary manner. It is worth contemplating the fact that since 1950, applications of nitrogen fertilizer have increased about 20-fold (Smil, 2000, p109), while crop yields have gone up at most three-fold. While nitrogen is often a limiting factor for plant growth, if it were of overwhelming importance for plant production, we should see more proportional increases in yield, rather than such sharply diminishing returns.

17 'The importance of water-control techniques in contrast with irrigation is consistently underestimated in the literature. There is a wide range of these techniques, including those that just hold water in the sandier soils [by increasing soil organic matter] as well as a series of measures to reduce runoff where crusting is the problem. These are not just indigenous techniques. The most important ones in the next decade have large potential yield effects (when combined with inorganic fertilizers) and need to be undertaken during the crop season, generally with animal traction, and not just as emergency measures on the most degraded or most easily degraded regions (hillsides)' (Sanders, 1997, p19). On this point generally, see FAO (1994).

18 In the rice–wheat rotation systems widely used in the Indo-Gangetic Plains of South Asia, certain kinds of ploughing techniques, adjusted by depth and timing, can retain enough water from the rice season for the following wheat season, so that the amount of water needed for the latter crop is reduced (personal communication, Craig Meisner, CIMMYT/CIIFAD). Seeding wheat in the standing rice crop towards the end of its growing season enables the wheat crop to benefit from residual soil moisture, reducing the need for irrigation (personal communication, Peter Hobbs, CIMMYT). These low-till methods are being promoted by CIMMYT and IRRI because they can save water, raise yields, lower production costs, reduce weeds and herbicide use, plus reduce greenhouse gas emissions ('New Movement Among Farmers to Give Up the Plow Takes Root', press release from Future Harvest, The Hague, 2 October 2001, http://futureharvest.org/new/lowtill.shtml).

19 Most of the ideas in this chapter have been prompted from the co-authors' interactions with colleagues at Cornell University and in developing countries where CIIFAD has been engaged in collaborative, interdisciplinary programmes since 1990 to further the prospects for sustainable agricultural and rural development (Uphoff, 1996a). It is hard to know where ideas come from, and to give full or proportional credit where it is due. We take responsibility for presenting these ideas for critical consideration by researchers and practitioners, not claiming personal credit for all of them, and acknowledging our indebtedness to colleagues at Cornell and elsewhere for the stimulation and challenge they have contributed to this thinking. Critical review by Rainer Assé and Christopher Barrett of the whole manuscript was particularly helpful.

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18

Integrated Farming Systems at Different Scales

Li Wenhua

Major types of integrated farming systems (IFS) have various structures and technical features. Integrated farming systems can be implemented at various scales. According to the sizes and characteristics, IFS can be classified into micro-, medium- and macro-scales. In this chapter we will present a general review of the major types of IFS as used in homestead gardens, eco-villages, eco-counties and forest shelterbelts.

Homestead Garden Ecosystems

Introduction

Homestead gardens, as a form of IFS on a micro-scale level, can be found on every continent. Apart from China, many other Asian countries, such as Indonesia, India, Sri Lanka and Bangladesh, are well known for their homestead gardens (Li Fadi, 1993; Li et al, 1994). Fernands and Nair (1986) put forward a definition based on their research on tropical agroforestry: '[A] homestead garden is an artificial diversified method of using trees, bushes, perennial crops and diversified poultry in the same courtyard in close combination. This compound unit of trees, crops and animals is usually managed by family members.'

China has a long history in the development of the homestead economy. Production from the home has become an important part of the self-sufficient rural economy and an important source of income for farmers. The farmers plant trees, crops, vegetables and raise livestock or fish in their yards mainly for their daily sustenance. In this way, farmers can make full use of natural resources, labour, techniques, funds and working time for agriculture, forestry, animal husbandry, fishery and sideline processing. Thus, house construction, agriculture and humans

Reprinted from Chapter 12 – Integrating farming systems at different scales, pp210–252, in Li Wenhua, *Agro-Ecological Farming Systems in China*, Man and the Biosphere Series Volume 26

together form an integrated holistic system with high economic, ecological and social benefits.

China has a high and increasing population but the growth rate of the family, due to implementation of family planning, is decreasing. On the other hand, the number of families has been increasing at a growth rate of about 3 per cent per year which, in comparison with the growth rate of the general population, is much higher. In rural areas, each individual family is allotted a small piece of land for the construction of a house and some homestead production activities. At present China has a total of 180 million families in the rural areas. The amount of land distributed to each family depends on the size of the family and the region. In general, it averages about 0.02ha per household.

It is interesting to note that though farms occupy a certain amount of land, decreasing the total arable land, total production has not decreased. This is due to integrated production and intensive management. Although sometimes homestead gardens appear to be a random mixture of trees, shrubs and herbs, a certain general pattern does exist. The components are very intimately mixed in horizontal and vertical strata, as well as in time. Complex interactions exist between the soil, plants and other components and their environment in the plots around the house.

General structure and components of homestead gardens

A homestead garden in China consists of a number of tree and fruit species and provides both productive and protective functions. Among these, poplar, willow, elms, *Sophora* and varieties of fruit trees like apple, pear, peach, date palms, *Ailantus* as well as vineyards, are common in temperate regions. In the subtropical region the litzhii, rangon, *Eryobotrya*, melia, orange and bamboo are the most common woody species. In the tropics the mango, palm, banana, jack fruit, papaya, tamarind and other tropical fruit trees are widely planted on homesteads. At ground level, a wide variety of vegetables, medicinal herbaceous plants and flowers are commonly cultivated in homesteads.

Most farm families raise a variety of animals, such as cows, buffaloes, bullocks, pigs, sheep, rabbits, chickens, ducks and geese. In the low-lying regions of southern China, on the marshlands of northern China and in coastal areas, aquaculture and mariculture is extensively practised on homesteads adjoining canals, paddy fields and ponds. Sometimes earthworms and eels or other marketable aquatic animals are also involved in these systems.

A typical homestead with a multitude of crops presents a multi-level canopy configuration, particularly in tropical areas. The leaf canopies of the components are arranged in such a way that they occupy different vertical layers, the highest level having foliage tolerant of strong light with high transpiration demands and the lower-level components having foliage requiring or tolerating shade and high humidity. Many cash medicinal plants are also permanent components of homestead gardens. Figure 18.1 shows a typical homestead garden ecosystem.

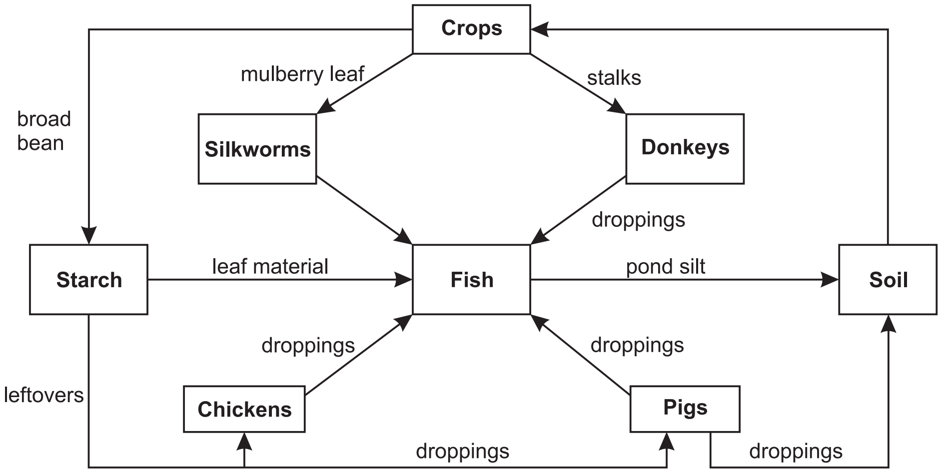


Figure 18.1 *A typical homestead garden ecosystem*

The components on the homestead are also selected according to the necessity of providing material for cottage industry and sideline handicraft production. For example, in the subtropical provinces of southern China, bamboo is planted around the family dwellings to provide material for weaving different bamboo products. The implementation of biogas production is also an important aspect in making up for the shortage of rural energy. It also strengthens the chain of nutrient cycling within the system.

Major types of homestead garden

Due to the vast area of territory and great variety of physical, economic and social conditions, different types of homestead gardens have been formulated. These can be divided into five categories, based on the components, structure and the way of management.

Cultivation–breeding

This is the most popular type of homestead garden in China. The animals include chickens, ducks, fish, hares, oxen, horses, pigs, sheep, bees, birds, earthworms, dogs, martens, scorpions and coypu. The relationship between different components may be true predators, grazers, parasitoids and parasites. But most interactions between them are through the influence of physical environmental factors.

Courtyard with dominance of woody species

With the aim of producing wood, fuel materials, fruit and attaining protection, this type is relatively simple in composition and management. The tree plantation is at the centre of the ecosystem. In fact, because of the usage of forest, there are several different forms:

- Courtyard dominated by timber tree species: In this type farmers plant trees and shrubs in and around their courtyard. The tree species differ according to local conditions and farmers' interests. In successfully afforested districts, quick growth and high yield forest are common. This type of homestead is often seen in areas with a shortage of timber and fuel in northern and north-western China.
- Courtyard with dominance of fruit trees: This is characterized by planting fruit trees around/in courtyards, mostly in the form of an orchard, but sometimes there are only a few fruit trees or even a single fruit tree in a courtyard. Species of fruit trees vary with region. For example, apricot, cherry, jujube, stone pomegranate, apple, pear, mandarin orange, tangerine, orange and grape.
- Courtyard dominated by tree seedlings and other cash tree species: in some regions, where the market is available, farmers are engaged in tree seedling cultivation. In other areas farmers are interested in cultivating cash tree crops, such as magnolia, *Eucommia* and honeysuckle, which usually create high profits.

Multi-dimensional cultivation

In order to fully use all the resources in space and in time, peasants usually design multi-dimensional homestead systems consisting of trees, crops, vegetables and edible fungi. There are several forms including:

- timber/fruit trees + melon and/or vegetables;
- lumber/fruit tree + edible mushrooms;
- trees + medicinal plants; and
- trees + flowering plants.

Cultivation–breeding–processing combination

This is developed on the basis of cultivation–breeding type in combination with some processing industries. These include handicrafts and small cottage processing industries:

1. Timber–fruit processing. This includes wood processing and craftwork such as grass weaving, bamboo weaving, furniture making and fruit processing. Farmers can gain high economic benefit if their processed products meet the needs of markets.
2. Cultivation–breeding–processing industry. This combines agriculture, animal breeding and horticulture with small agriculture processing industry in a household system. The cultivated species depend on the natural conditions of the areas. The waste from the family and the residue from agriculture harvests are used to feed domestic animals, while grains are subjected to simple processing to meet dietary requirements. The vegetables, besides being grown for consumption, can be preserved in the form of pickles and salted vegetables.

Cultivation-breeding-processing-energy integration
This is the most complex system at household level. Residents, homestead gardens, domestic animals and biogas generating facilities are well integrated into a system. It is not possible to give detailed descriptions of all the varieties and we present a case study to show how farmers manage their small homestead with full use of resources and to optimal effect.

A case study – Zhangxi's household ecosystem

Structure of the household ecosystem
Zhangxi is a farmer of Shilihe village, Sujiatun district of Shenyang City, Liaoning Province. There are three people including workers in his family, with a total area of 605m^2, of which the house area is 91m^2 and the garden area is 220m^2. In the spring of 1990, with the guidance and help of scientists, Zhangxi rearranged his household system. The optimized household ecosystem is divided into a number of basic subsystems: plastic shed, biogas digester, pig sty and toilet, garden and residents.

- A plastic shed with an area of 136.5m^2 was built in front of the house. Oyster mushrooms were planted twice within a year, first in summer (from August to the next November) and then winter (from November to the next June).
- A biogas digester with a volume of 7.5m^3 is set underground in the west of the shed, and a pig sty and toilet are constructed on the biogas digester. The human and animal faeces and urine are put into the digester automatically, to produce biogas for illumination and fuel.
- A 19.5m^2 pig pen and toilet was arranged above the biogas digester.
- The area of fields for the household is 220m^2.
- There are three persons in the family encompassing the resident subsystem.

Energy analysis and nutrient balance of the household ecosystem
The energy flow of household ecosystems is divided into three categories: energy input from outside of the ecosystem (Table 18.1), between components within the ecosystem, and the energy flow from the system to outside. Tables 18.2, 18.3, 18.4 and 18.5 describe the nutrient balances in the plastic shed subsystem, biogas digester subsystem, pigpen subsystem and garden subsystem, respectively.

Benefits analysis
It is evident that the household ecosystem is an efficient, highly productive system with considerable, comprehensive benefits. The subsystems closely interact with each other. With accumulation of productive experience and improvements in techniques, the yield of crops increased from June 1994 to May 1995. The total material was 9250kg, and 8000kg of oyster mushrooms were produced, the increase in benefit was nearly doubled. In general, the biogas pond can produce about 150m^3 of biogas used by the family and 1400kg/yr of biogas sediment which is used in the garden (roughly 150kg) and the fields outside of the household (roughly 1250kg). In

Table 18.1 *Energy flow of the household ecosystem (June 1992 to May 1995 means)*

Item	*Quantity/yr*	*MJ/yr*
I. Solar energy	448,600MJ	448,600
II. Industrial energy	18,919MJ	18,919
1 Insecticides	6kg	2183
2 Chemical fertilizer	20kg	342
3 Plastics	45kg	4712
4 Machinery and tools	0.41kg	31
5 Electric	700kwh	8393
6 Coal	1 ton	3259
III. Biomass input from outside the system	127,424MJ	127,424
1 Grain and soya bean oil	525kg	9156
2 Feed	3255kg	36,411
3 Cultural material for edible mushrooms	6683kg	80,381
4 Pigs	88kg	1477
IV. Human labour	2345h	1759
V. Biomass harvested from the system		
1 Vegetables	375kg	330
2 Grapes	250kg	230
• Consumption by residents	25kg	23
• Export to market	225kg	207
3 Oyster mushrooms	5717kg	27,394
• Consumption by residents	50kg	240
• Export to market	5668kg	27,155
4 Pork		
• Consumption by residents	45kg	759
• Export to market	780kg	13,159
5 Residue after cultivating oyster mushrooms	4484kg	19,351
• Feed	385kg	1661
• Stored compost returned to farmlands	4099kg	17,689
VI. Biogas and manure from the system		
1 Biogas	150m^3	3135
2 Animal and human manure	2150kg	38,195
3 Biogas manure	1400kg	24,878
• For gardens	150kg	2666
• For farmlands	1250kg	22,213

addition, in the homestead garden, about 10 pigs are raised twice a year and 375kg of vegetables can be provided for the whole family. About 250kg of grapes are harvested per year from the 40 grape vines planted in the garden.

Perspectives

Merits of the homestead garden ecosystem

Generally, a homestead garden ecosystem has significant economic, ecological and social benefits and farmers therefore take a positive attitude to this practice. Since

Table 18.2 *Analysis of nutrient balance in a plastic shed subsystem*

Item	*Quantity/yr*	*N*	*P_2O_5*	*K_2O*
Input material for cultivating oyster mushrooms	6683.40	37.26	65.12	46.42
Output of oyster mushrooms	5717.50	19.12	28.51	15.87
Consumed by residents	50.00	0.17	0.26	0.15
Export to market	5667.50	18.95	28.25	15.72
Residue after cultivating oyster mushrooms	4484.23	18.39	33.95	30.25
Pig feed	385.00	1.58	3.09	2.60
Stored compost returned to farmlands	4099.23	16.81	32.86	27.65

Table 18.3 *Analysis of nutrient balance in a biogas digester subsystem*

Item	*Quantity/yr*	*N*	*P_2O_5*	*K_20*
Inputs				
Human faeces (fresh weight)	273.00	2.84	0.98	0.93
Human urine (fresh weight)	2190.00	9.42	1.32	6.13
Pig faeces (fresh weight)	3759.50	22.56	16.92	18.80
Pig urine (fresh weight)	5665.00	17.00	7.36	11.33
Total		51.82	26.58	37.19
Outputs				
Biogas manure (dry weight)	1000.00	16.20	19.70	5.50
Biogas liquid (fresh weight)	2000.00	22.00	6.80	12.60
Total		38.20	26.50	18.10

Table 18.4 *Analysis of nutrient balance in a pig pen subsystem*

Item	*Quantity/yr*	*N*	*P_2O_5*	*K_20*
Input				
Feed	3255.00	65.43	43.62	31.90
Output				
Pig faeces (fresh weight)	3759.50	22.56	16.92	18.80
Pig urine (fresh weight)	5665.00	17.00	7.36	11.33
Pig catch (pork)	825.00	25.87	19.34	1.77

1980 many scientists and organizations have undertaken homestead garden ecosystem studies. Among the most significant is the Shijiazhuang Agricultural Modernization Institute, CAS, which made special and systematic studies and published a series of research articles. Numerous examples indicate that the land productive ratio of homestead garden ecosystems is much greater than that of general farmland. On

Table 18.5 *Analysis of nutrient balance in a garden subsystem*

Item	*Quantity/yr*	*N*	*P_2O_5*	*K_20*
Input				
Biogas residue manure (dry weight)	150.00	2.43	2.96	2.33
Biogas liquid manure (fresh weight)	200.00	2.20	0.68	2.16
Total		4.63	3.64	4.49
Output				
Vegetables (fresh weight)	375.00	1.80	1.01	1.95
Grapes (fresh weight)	250.00	1.50	0.75	1.80
Total		3.30	1.76	3.75

average, income of homestead garden ecosystems is six times that of farmland output for the same area unit. Therefore, the potential productivity of homestead garden ecosystems should not be overlooked (Yun, 1989). In summary, homestead garden ecosystems have a number of merits:

1 The multitude of crop species and animals on homesteads helps to satisfy the needs of farmers on subsistence economy.
2 The mixed feature of home gardens leads to substantial improvements in the physical and biological characteristics of the soil and environment.
3 The immediacy of human involvement and the full utilization of human waste can reduce pollution of the environment.
4 The convenient location of home gardens provides the possibility to effectively utilize family labour. Much work can be accomplished during time free of field work. The old men and women can also participate without wasting time obtaining garden plots.
5 The ratio between input and output is higher than that of conventional work in the field.
6 A special microclimate is created within homestead garden ecosystems.

Existing problems of homestead gardens

However, there are some constraints to homestead garden ecosystems. At present, the following problems shouild be seriously considered:

- Some villages and small towns lack suitable development programmes for homestead gardens. Most villages have narrow streets, small lanes, polluted water, barnyard manure in the street, threshing grounds and processing factories.
- Private houses and courtyards lack satisfactory design criteria. Not all farmers have the knowledge to organize the different components in a proper manner. This leads to a reduction in yields of individual understorey crops. Many farmers do not plant and breed suitable species, based on the space available and the food chain.

- The structure of homestead gardens is usually simple and the management level is very poor. Many profitable plant and animal species have not been introduced into the system and many advanced techniques have not been adopted. Therefore, the trees grow poorly, fruit trees and animal outputs are low, and biogas production is inefficient.
- Environmental quality of rural areas is subject to inadequate homestead garden ecosystem management. In the ecosystem, oxen, pigs, chickens, ducks, dogs, cats and humans live together in a small courtyard. Some common diseases may possibly spread. In the humid tropical and subtropical areas, a high plant density on homesteads can cause fungal diseases, especially during the rainy seasons. Sometimes, faulty utilization of wastes causes pollution.

Eco-village

Introduction

As the concept of sustainable development has spread across the world since the 1980s, a vehement campaign for Ecological Demonstrative Rebuilding for Sustainable Settlements (EDRSS) has taken place in China and many projects for ecopolis, eco-county, eco-village, as well as eco-householders were initiated and carried out across the country. The EDRSS projects were aimed at implementing the principles of IFS to the practice of local development and to explore further specific operational approaches to achieve sustainable development at different levels. Recently, great progress on EDRSS projects has been made, and eco-villages are conspicuously emerging as fruitful examples, displaying some valuable experience in human ecological rebuilding.

Main types

The eco-village is a special kind of ecological engineering, in which primary production, secondary production and cottage processing industries are integrated into a self-regulating sustainable system at the village/township or agriculture/breeding farm level. Different combinations and structures have been developed in accordance with different physio-geographical and social conditions. In China, there are many successful examples of eco-village construction. A number of projects have received awards for 'Best Eco-village' at national and international levels. In general, according to the combination of different sectors, we can classify them into six models:

1 Combination of agriculture and cottage industry. Liumingying eco-village is a good example of this and will be described later in the case studies.

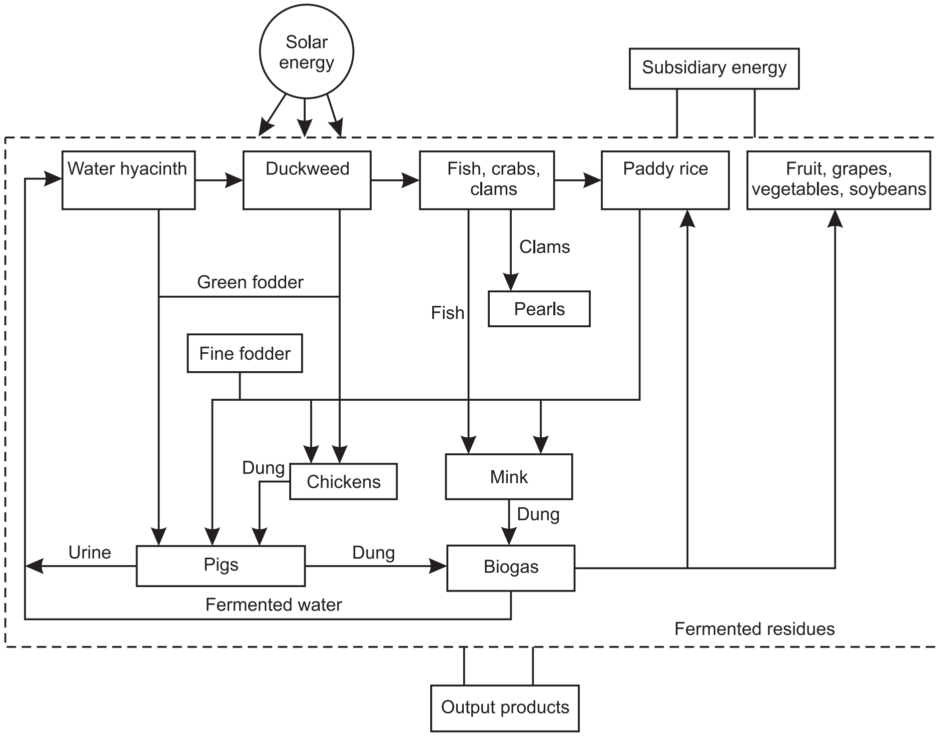


Figure 18.2 *The scheme of Xi'an eco-farming*

2 Combination of animal breeding and aquaculture. Figure 18.2 shows the Xi'an Breeding farm of Dawa County, Liaoning Province, a typical example of combining animal breeding with aquaculture and forage production.
3 Combination of agriculture, animal husbandry and cottage industry. The Xishan village in Zhibo City of Shandong Province has created a successful model combining agriculture with animal husbandry and cottage processing industry.
4 Combination of agriculture and forestry.
5 In southern China, combinations of aquaculture, animal husbandry and agriculture are very popular.
6 Integrated development model in degraded ecosystems. In degraded areas, eco-restoration, eco-reconstruction and eco-development are very important. Hongzhuang village of Huaibei City, Anhui Province, has created a special kind of sustainable agricultural development model near a coal mine.

Having recognized that it is impossible to give a detailed introduction to all of the different kinds of eco-village models, we will only take Shandu and Liumingying eco-villages as examples to show how the eco-village in China is organized and functions.

Case study I: Shandu eco-village

Background

In Jiande City of Zhejiang Province, an ecological demonstrative project, The building of Grand Shandu Eco-village System was launched in 1988, and has made remarkable achievements in the course of pursuing village-level eco-construction.

Grand Shandu Eco-village System (GSES) is located at the confluence of the Xin'an, Lan and Fuchun Rivers, consisting of four small villages. In 1988, when the demonstration project of GSES was initiated, there were 888 households with a total population of 3211. The total area of the project was 1225.54ha, of which arable land, hilly land and waterbodies were 1557, 7384 and 137.47ha, respectively [*sic*]. Gross agricultural revenue was only 2.78 million *yuan* RMB and annual income was 602 *yuan* RMB per peasant. There were only a few small cottage factories, such as an umbrella manufactory, a tea processing factory and an electroplating factory. The total output value of the village industry amounted to 11.50 million *yuan* RMB. Before implementation of the project, the main constraints to development of these villages were:

1 Low-efficiency in exploiting natural resources. The forest coverage was relatively low with barren land and mountains of 146.67ha. A large waterbody was not completely exploited.
2 Irrational structure of different sectors in agriculture. In 1988, the total agricultural output value was 2.88 million *yuan* RMB, in which cereal crops, forestry, husbandry, sidelines and fishery occupied 21.88 per cent, 58.23 per cent, 11.61 per cent, 2.35 per cent and 5.93 per cent, respectively. The latter three were relatively underdeveloped.
3 Reduction of soil fertility and topsoil depth. Because of long-term over-cultivation and high input of chemical fertilizers (the average fertilization was 3157.5kg/ha), arable land with a depth of topsoil below 13cm occupied more than 50 per cent of the total area of arable land. Fifty per cent of the land had low organic matter content (below 1.5 per cent) and all arable land had a low content of phosphorus and potassium.
4 Inefficient utilization and protection of water resources. The total water area used for fishery was only 6.93 ha, a mere 5 per cent of the total, and some parts were ecologically damaged due to over-fishing.
5 Backward village infrastructure and irrational land-use layout. Scattered houses, narrow roads and poor sanitary conditions were some typical features due to the lack of general village planning and insufficient investment.
6 Large amount of pollution emissions from rural industry. The mediocre and outmoded technical equipment used in village enterprises caused heavy pollution and environmental degradation.

The construction of GSES

In 1988, in order to promote sustainable development at the village level, the GSES project was launched. A comprehensive plan was made and a series of measures were adopted.

1. Planning and design

Based on the overall survey and assessment, and according to principles of IFS, a comprehensive four-year plan for GSES development was prepared. This aimed at promoting sustainable development with consideration for the relationship among population, resources, environment and economic development. The targets and the main contents of the plan included:

- Economic aspects. Readjusting the proportion of agriculture and industry and making industrial output value 74 per cent of the gross output value of industry and agriculture, and doubling annual per capita income.
- Environment and resources aspects. Ameliorating soil deterioration with the goal of increasing organic matter in topsoil to 2.5–3.0 per cent, developing biogas and other new energy resources, integrating agricultural by-products and organic wastes; cutting down the amount of pesticide usage, and disseminating the integrated techniques for disaster and pest control.
- Enhancing treatment capacity of 'three wastes' (gases, water and solids) from rural industry and making the emission amount within the limitation of the State's Second-class Standard, and reforesting barren hilly lands so as to raise forest coverage to 60 per cent.
- Social and cultural aspects. Setting up a hospital and sanitorium department, building a primary school, constructing a house for the aged, improving the original kindergarten, strengthening construction capacities by professional training and other educational activities, and reducing population growth rate to less than 1 per cent.
- Village infrastructure. Constructing two highways and building 500 dwelling houses.

2. Major measures

In order to realize the goals mentioned above, seven major measures were taken:

1. Readjusting the agricultural structure and promoting the overall development of ecoagriculture. The structure of agriculture of GSES was modified from the two-component-dominated pattern (agriculture + forestry) to a five-component balanced pattern (agriculture + forestry + animal husbandry + sidelines + fishery). Within the composition of agricultural output value, the contributing rate of forestry and animal husbandry was adjusted upward, while crop planting was adjusted downward and sidelines and fishery were slightly reduced. As a result, the total output value has grown drastically (Table 18.6). In the process of the readjustment of agricultural land use, the cultivated area of cereal

Table 18.6 *Readjusted sectorial composition in total output value from 1988 to 1991 (Unit: 10 thousand yuan RMB)*

Year	*TOV*	*CP*		*FO*		*AH*		*SI*		*FI*	
		Sov	*Per*	*Sov*	*Per*	*Sov*	*Per*	*Sov*	*Per*	*Sov*	*Per*
1988	287.98	63.02	21.88	167.70	58.23	33.41	11.60	6.77	2.35	17.08	5.93
1991	666.92	86.30	12.94	457.77	68.6	88.60	13.28	12.95	1.94	21.30	3.19
RGR (%)	131.59	36.94		172.97		165.19		91.29		24.71	

Notes: TOV: Total output value; CP: crop planting; FO: forestry; AH: animal husbandry; SI: sideline; FI: fishery; RGR: Relative growth rate to 1988; Sov.: Sectorial output value; Per.: Percentage of sectorial output value to total.

Table 18.7 *The output from different sectors of agriculture*

Year	*Total yield of grain (tons)*	*Yield of fruits (tons)*		*Chickens*	*Eggs (tons)*	*Honey (tons)*
		Total output	*Citrus yield*			
1988	1708	1559.3	1525	16,790	38.4	32.7
1991	1899	5402.5	5390	38,475	115.1	36
RGR (%)	111.18	246.47	153.44	129.15	199.74	100.09

Notes: RGR: Relative growth rate to 1988.

crops was kept between 120 and 126.67ha, and the production of fruits was enhanced by extending the area and increasing per unit area yield. In addition, 55,000 citrus trees were planted along the river banks, roadsides and field ridges. In the meanwhile, aquaculture has been greatly developed by using by-products of crops to process fodder. From 1988 to 1991, the yield of farm products rose, and remarkable economic benefits have been achieved (Table 18.7).

2 Developing IFS based on ecological principles. Large areas of waterbodies were effectively protected and reasonably exploited. The protection of water resources was a first priority. Advanced aquaculture techniques were introduced to increase yields. Chicken-raising and fishery cultivation were deliberately arranged according to energy flow and food chain principles. The fertility of topsoil was further improved by increasing the input of manure and decreasing the amount of chemical fertilizer (Table 18.8). Afforestation were carried out mainly in the rolling land, which accounted for 451.33ha or 60 per cent of the hilly land of the village. From 1988 to 1991 the total area of afforestation on the rolling hilly land reached 386.67ha and forest coverage rate rose from 42.4 per cent in 1988 to 70 per cent in 1991.

3 Developing the courtyard economy and constructing eco-households. A special type of animal husbandry-dominated courtyard economy was developed in GSES. About 262,000 fruit trees were planted in the courtyards with

Table 18.8 *The change in soil fertility from 1988 to 1991*

Year	*Organic matter (%)*	*Nitrates (ppm)*	*Available potassium (ppm)*	*Available phosphorus (ppm)*
1988	2.58	63.64	136.18	16.67
1991	2.63	70.64	141.72	16.81
RGR to 1988 (%)	1.94	11	4.07	0.84

3.77 million kg of fruits of different varieties harvested each year. The output value of courtyard husbandry reached 80,000 *yuan* RMB in 1991. In 1990 a biogas engineering project was installed in ecological demonstration households, using the dung of chickens, pigs and humans as raw material. A 13m^3 biogas pit was built in each household. These biogas digesters could produce 1660m^3 biogas per year, which can save 9960kg of firewood. The remaining liquid and sludge from biogas pits was returned to the fields as good quality manure to improve soil fertility or to feed fish. Until 1991, 100 ecological demonstration households were constructed, accounting for 12 per cent of the total.

4 Establishing multi-step utilization and regeneration of agricultural by-products and 'wastes'. In the village there were 33 households raising 2,164,000 chickens, and all the chickens' faeces were used to feed fish, giving an annual saving in fish fodder of 113.6kg. The second application of eco-engineering was a mulberry–silkworm–pig–crop integrated production system: (i) mulberry was cultivated to produce leaves used as forage for silkworm; (ii) the silkworm chrysalis was used for raising pigs; and (iii) the faeces of pigs was returned to the fields as fertilizer. These three integrated steps constituted a complete ecological recycling chain. In 1991 the net income from silkworm cocoons, pigs and grains reached 3.19 million *yuan* RMB, 58.91 per cent more than that of 1988. A third type of eco-engineering was a chicken–pig–mushroom–biogas integrated production system.

5 Reorienting village enterprises toward environmentally healthy development. Following regulations for environmental protection, some lower-pollution or non-pollution enterprises were encouraged. Meanwhile, some strict measures were taken in heavy-pollution enterprises in order to control emissions. By 1991 the wastewater emitted from heavy-pollution enterprises such as the Shandu Electroplating Factory and the umbrella manufactory had met the State's Second-class Standard of environmental control (Table 18.9). After four years, significant environmental benefits had been attained. Table 18.10 shows the improvement in the quality of water through specific treatment, and Table 18.11 shows improvement in quality of soil. The treated rate of the 'three wastes' from village enterprises rapidly approached zero by 1991.

6 Improving village infrastructures and life quality. According to the general development plan of 1988–1991, a number of new projects for strengthening

Table 18.9 *Status of waste water from heavy-pollution enterprises*

Year		*Indicator pollutants (mg/l)*				
	pH	*CN^-*	*Cr^{6+}*	*Cu^{2+}*	*Zn^{2+}*	*Ni^{2+}*
1988	3.50	0.50	21.90	0.78	1.69	10.65
1991	6.94	0.38	0.23	0.23	0.30	0.81

Table 18.10 *Improvement in water quality through specific pollution treatments from 1988 to 1991*

Sampling place	*Concentration of pollutants (mg/l)*						
	Year	*COD*	*Cr^{6+}*	*NH_3-N*	*Volatile phenol*	*Hg*	*Cu^{2+}*
Shando Bay	1988	4.59	0.023	0.20	0.002	0.05	0.007
	1991	2.07	0.004	0.20	0.002	0.05	0.007
Jiangjunyan	1988	3.20	0.004	0.66	0.002	0.05	0.007
	1991	2.74	0.004	0.91	0.002	0.05	0.007
Lanjiangkou	1988	3.32	0.004	0.71	0.002	0.05	0.007
	1991	2.46	0.004	0.45	0.002	0.05	0.007

Table 18.11 *Improvement in soil quality from 1988 to 1991*

Year	*Concentration of pollutants (ppm)*									
	Total Cr	*Cd*	*Zn*	*Cu*	*Ni*	*Fe*	*Pb*	*Mn*	*BHC*	*DDT*
1988	10.61	0.18	73.46	14.16	12.85	31,158.5	29.48	434.09	0.06	0.21
1991	4.50	0.11	61.13	13.64	10.01	34,257.7	14.00	335.38	0.04	0.19
Increase relative to 1998	–57.59 (%)	–37.93	–16.73	–3.60	–22.10	995	–18.46	–22.74	–39.57	–11.35

infrastructure were implemented. As per this plan, 524 dwelling houses were built with per capita living space of 72m². Investment was provided to expand teaching facilities and improve living conditions of the village's teachers. The total area of buildings for middle schools was expanded by 1500m², a primary school was set up with an area of 300m². The highways in GSES were expanded by 5000m.

7 Promoting capacity building. A series of eco-educational activities were conducted through broadcasting, a blackboard newspaper and meetings. In addition, the authorities of the villages organized a series of training courses to disseminate useful techniques and knowledge to improve working skills of the farmers.

Benefits and experiences

The four-year practice of the GSES project achieved remarkable economic, social and ecological benefits. The total output value of industry and agriculture reached 26.34 million *yuan* RMB in 1991, or 83.07 per cent more as compared with that in 1988. The gross profit of the village economy amounted to 7.31 million *yuan* RMB, or 163.49 per cent as compared to that in 1988, and per capita income reached 1621 *yuan* RMB. increasing 169.27 per cent as compared to that of 1988. The social development of the village had ended its vicious circle and transferred from poverty to economic prosperity and ecological sustainability. The main experiences of GSES construction can be summarized as follows:

1 implementation of IFS in environmental protection and comprehensive utilization of resources;
2 overall planning and design for the integrated village development;
3 establishment of corresponding institutions to manage the relationship between humans and the environment; and
4 development of local culture and capacity building toward sustainable development.

In summary, GSES presents a successful example for sustainable development at the village level in China. Perhaps some of the experiences could also be useful for other countries, especially the developing countries, for finding their own methods in eco-village construction.

Case study II: Liuminying eco-village

Background

Liuminying Village is situated in Daxing County, about 50km from Beijing. It has a total area of 14.7ha, of which 11.6ha is arable land. The population totals 898, including 560 workers. Liumingying used to be an area of saline–alkaline soils with acute shortage of fertilizer, fuel and forage. Peasants could not earn enough to support their families and had to depend on government help. Before implementation of the programme of IFS, production was mainly concentrated in agriculture and more than 95 per cent of workers were engaged in crop production. The gross production of the village was 680,000 *yuan*, of which 78 per cent was from agriculture. The average per capita income was only 405 *yuan*. Due to long-term and excessive input of chemical fertilizers, accelerated degradation of soil and pollution of the environment had occurred.

The construction of Liumingying eco-village

In early 1983, the design for the eco-village was implemented, with help of scientists. An important step was to manipulate the production structure from monocultivation to multi-components and integrative production systems. The production system of the village comprises three interlinked subsystems. The first is the crop-cultivation subsystem including cereal crops, vegetables and fruit; the second is the breeding subsystem involving chicken breeding, duck breeding, pigs, milk cow breeding and aquaculture; and the third is the industry-sideline production subsystem, including a number of cottage industries for processing agricultural products, such as a flour processing factory, a fodder processing factory, a soft-drink production factory, a slaughter and meat processing factory and a sweet porridge factory.

In order to solve the problems of shortage of firewood and link different compartments of the production system into an integrated system, one of the successful experiments was the development of biogas. The biogas system consisted of four components:

1 Straw of grain crops, residues of vegetables and by-products from food processing were used to feed cows and pigs.
2 The faeces and urine from cows and pigs were put into biogas ponds as raw materials for biogas generation.
3 Biogas was used for cooking, water-heating and lighting.
4 Biogas residues and liquids were used as fertilizer for fishponds, vegetables or crop cultivation. Through this system, planting–animal husbandry–biogas generation–planting, or planting–agricultural product processing–animal husbandry–biogas generation–planting formed an ecological cycle with multi-energy utilization and material recycling (Figure 18.3).

In addition, in the eco-village an intensive material recycling system was also developed at the household level (Figure 18.4). A biogas generation pond was built in the homeyard, and connected to the toilet, pigsty and poultry breeding house. The excrement of animals was mixed with residues of vegetables and straws from crops

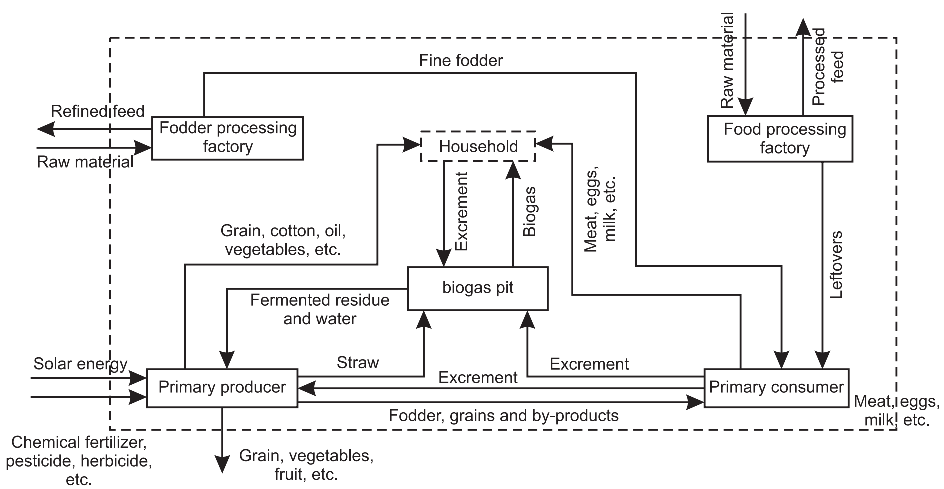


Figure 18.3 *General material flow in Liuminying eco-village (large cycle)*

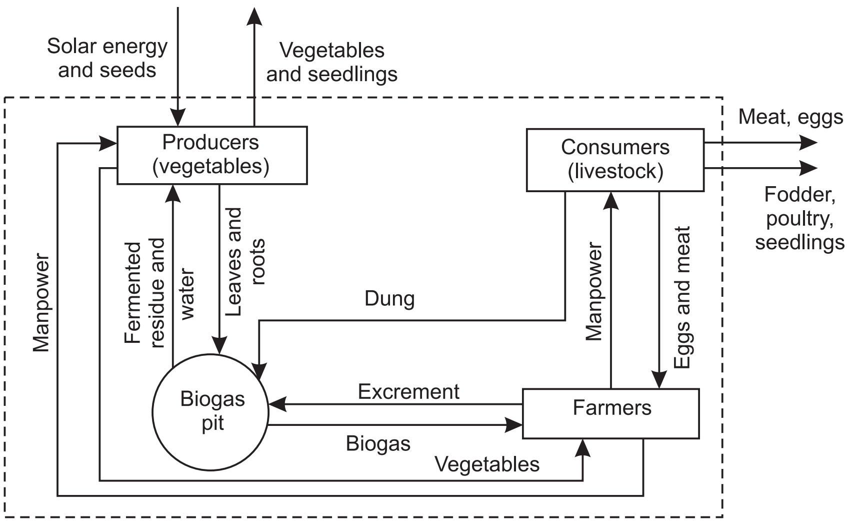


Figure 18.4 *Homestead garden ecosystem (small cycle)*

to generate biogas, which provides energy for cooking and lighting. The sludge from the biogas plant was used as fertilizer for agriculture or horticulture.

Benefits analysis

Through efforts in ecological construction, significant economic, ecological and social benefits were achieved.

Economic benefits

According to an estimate in 1993, the gross production of the village reached 100 million *yuan* RMB, of which 2.09 million *yuan* was from cultivation, 12.84 million *yuan* from animal husbandry, 400,000 *yuan* from forestry, 84.67 million *yuan* from cottage industry, of which 14.88 million *yuan* was net profit. The average gross economic growth rate of the village was as high as 57.2 per cent, and the average net profit growth rate reached 38.0 per cent (Table 18.12).

Ecological benefits

After over ten years' construction, the environmental conditions were much improved (Table 18.13). The Liumingying eco-village has been recognized by the national government as a typical model for development eco-villages in northern China and was among those awarded the World 500 best by UNEP.

Social benefits

Great progress has been achieved in social development, and this can be summarized:

Table 18.12 *Economic growth of Liuminying village*

Year	*1982*	*1985*	*1993*
Gross production (ten thousands *yuan*)	69	280	10,000
Net production (ten thousands *yuan*)	43	105	1488
Total area of fields (mu)	1900	1800	1200
Total yield of fields (10^4 kg)	89	103	120
Average yield (kg/mu)	468	572	1000
Average income per capita (*yuan*)	405	840	3703
Income per labour unit	750	1800	7206

Table 18.13 *Eco-environmental indices of Liuminying eco-village*

Year	*1982*	*1985*	*1993*
Light energy use efficiency (%)	0.55	0.70	0.90
Ratio of output to input of artificial auxiliary energy (%)	—	1.20	0.77
Ratio of organic/inorganic oxygen (%)	0.27	0.83	0.91
Ratio of nitrogen output to input (%)	0.25	0.52	0.76
Forestry coverage (%)	8.7	12.0	25.0
Ratio of economic output to its input to the total	2.66:1	1.60:1	1.18:1

1 The practices of Liuminying eco-village offer a successful model for agricultural modernization in rural areas of northern China.
2 IFS construction provides an effective approach to solve the problem of unemployment in rural areas.
3 IFS construction plays an important role not only in offering many agro-products and by-products, but also in enlivening the market economy.
4 In the process of IFS construction, a scientific and technical team were trained and awareness of sustainable development was greatly stimulated.
5 IFS construction promotes the development of a green food base and creates the environment to attract foreign investment.
6 The eco-village mitigates the differences between urban and rural areas and strengthens their interaction.

Eco-county

Introduction

In China, county is the most elementary unit in administration. It is relatively independent in policy making and administrative management. In general, a county has a land area of 1000–4000km^2 with a population of 0.2–0.8 million.

Since the 1990s, a county has been recognized as a basic unit for implementation of the strategy for sustainable development. A campaign for construction of eco-counties has been developed all over China. Eco-county construction is intended to enhance sustainable development capacity of the county by establishing ecologically sound production systems and management mechanisms through ecological engineering, ecological planning and ecological management. The construction of an eco-county requires complicated systems engineering and is multi-disciplinary. It needs the most extensive participation among decision makers, technicians and peasants and includes surveys, systems diagnosis, planning, demonstration, implementation and assessment (Figure 18.5).

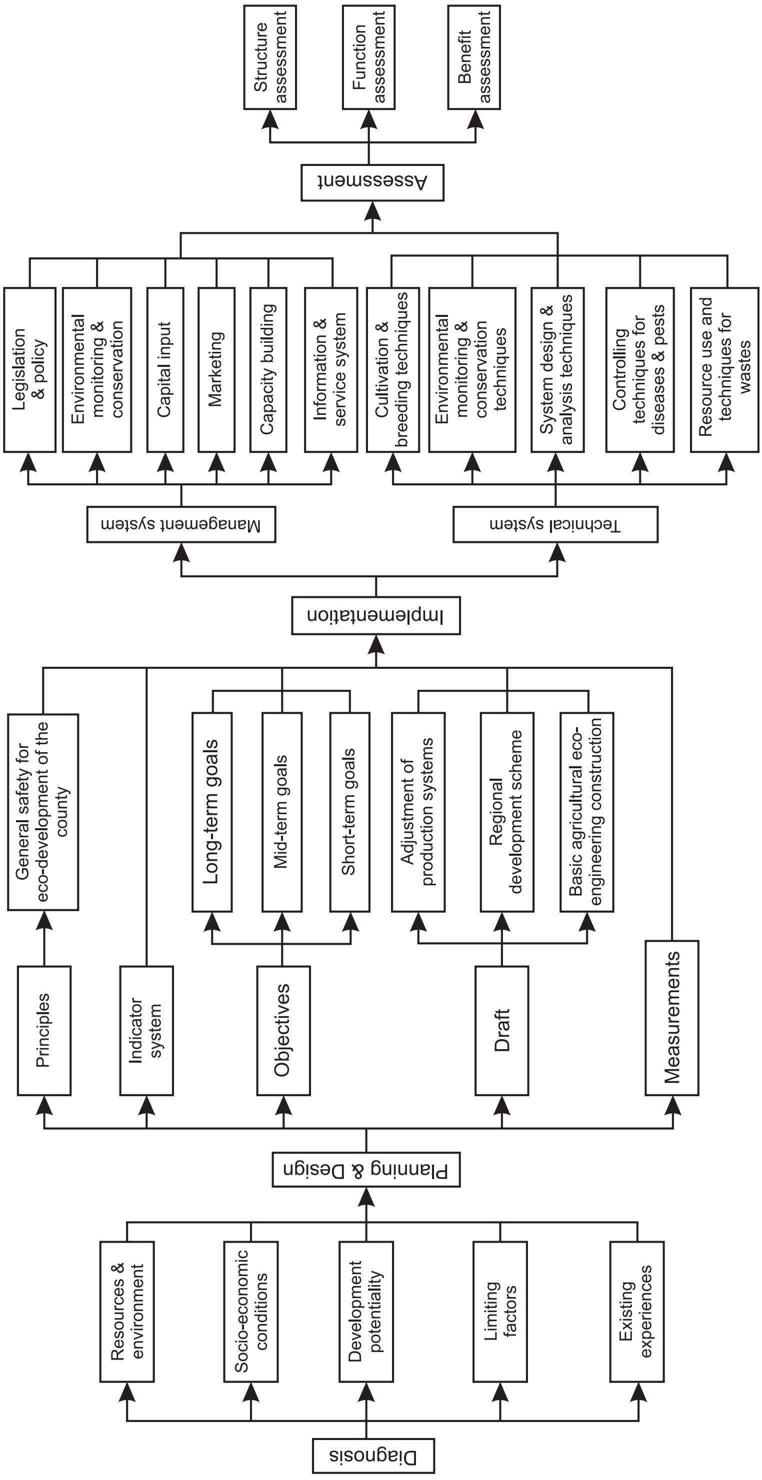
In order to promote the development of construction of an eco-county, a leading group was jointly organized by the State Planning Commission, State Commission of Science and Technology, Ministry of Finance, Ministry of Water Resources, Ministry of Forestry, Ministry of Agriculture and the State Environmental Protection Agency. Based on successful experiences in different physio-geographical and economic conditions, it combines development of models with demonstration and extension. Fifty-one counties with a total area of 120,000km^2 have been chosen as pilot sites for eco-county construction (Figure 18.6). In addition, there are many other demonstration and experimental sites constructed by other ministries or various local governments throughout China. Although eco-county construction is in the preliminary stage, it plays an important role in realizing the goal of sustainable development, especially in rural agriculture. For example, Baiquan County in Helongjiang Province is one of the best eco-counties.

Case study I: Eco-county construction in Yucheng

Background

Yucheng is located in the north-eastern part of Shandong Province, with an area of 990km^2 and 800,000 *mu* of arable land. It includes 18 townships with a population of 489,000. Yucheng lies in the warm temperate zone and the low-lying land along the ancient dykes of the Yellow River. The area is characterized by frequent drought in spring; water logging in autumn, followed by serious salinization of the soils. Agriculture production is low. According to statistical data from 1986–1988, the mean annual yields of grain, cotton and edible oil were 239.5, 38.4 and 56kg/*mu*, respectively, with per capita annual income of 187.6 *yuan* RMB.

In recent years, based on the principles of IFS, a massive campaign for construction of eco-counties for sustainable development has been conducted. On the basis of the development of the county as an integrated unit, a series of measures have been taken and remarkable progress has been achieved. According to the local natural and social conditions of the area, special attention has been paid to regulate agricultural structure, diversify agricultural products, make comprehensive use of natural resources, and ameliorate land conditions. A set of comprehensive techniques has been set up to deal with problems related to soil amelioration, water conservation and improvement of agricultural production.



Source: Li et al, 1994

Figure 18.5 *The procedure for an ecoagriculture county in China*

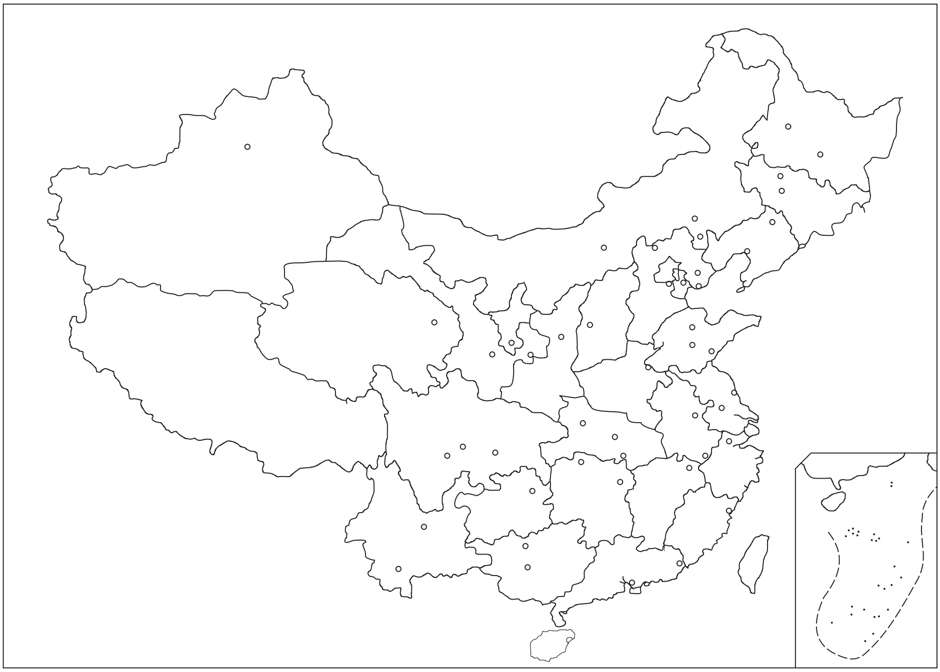


Figure 18.6 *Distribution of 51 ecoagriculture counties in China*

Major measures in construction of an eco-county

1. Regulation of agricultural structure

An important step for regulation of agricultural structure is to diversify agricultural production. Traditionally, Yucheng was a pure cereal crop area with a few animal husbandry practices. The straw of food crops was used as fuel or burned without utilization. Combining cereal farming with animal husbandry is a key measure for the regulation of the production structure. Cattle are the main domestic animals in the agricultural system. The approach for development of animal husbandry can be briefly summarized as 'Breeding by a single household, fattening by co-operative farms, and providing a service to society'. Currently, more than 90 households have cattle as a part of their agricultural management system. There are 45 accelerated fattening farms for cattle belonging to individual families. In every township a cattle breeding association has been established. A beef breeding cattle farm has been set up in the county. A beef processing factory with capacity of 50,000 butchered cattle was built in 1995. The number of big domestic animals has reached 350,000, or an average of 3.5 per farmer's family.

Along with the development of animal husbandry, silage techniques for wheat straw and green corn stems have been popularized as feed, which is good to eat, more digestible and more nutritious for cattle. The coarse protein content of fresh corn stems, which are rich in vitamins and minerals, is 1.6 per cent, 1.5 times more than that of wheat straw. According to random surveys, 18.7 per cent of farm families in the pilot area have used mixed feeds for pigs and chickens, and 53.2 per cent of families have begun to use mixed feeds with straw to raise cattle and sheep. These methods have led to a rapid growth in animal production and the meat(eggs) to feed ratio.

Because of the increase in the number of domestic animals and poultry, and the application of more organic fertilizer, the condition of salt–alkaline land has been improved and the yields of grain and cotton have increased. It is estimated that there are 1.6 million tons of manure produced in Yucheng every year. The organic matter content in the surface soil has been improved from 0.98 per cent in 1990 to 1.26 per cent in 1995 and the salt content of the ploughed layer has been lowered from 0.25 per cent to below 0.2 per cent. The effects of fertilizing and de-alkalinizing is significant. From 1994 to 1996, the government of Shandong Province organized on-the-spot meetings, and in 1995 Yucheng won an award as one of the ten best example counties in breeding cattle using crop stalks.

2. Combining agriculture with cottage industry

Stimulating the food chain structure of the ecosystem, the county combines agriculture production with industry so that primary productivity can be fully used and substances can be recycled and regenerated in effective ways. The government of Yucheng has developed brief and easily understandable guidelines for development of this interactive relationship as 'Township enterprises should be based on and supported by agriculture'.

3. Strengthening the linkage between production and scientific research

Since 1996, the Chinese Academy of Sciences (CAS) and the Chinese Academy of Agricultural Sciences (CAAS) have established an experimental station with a pilot area of 11.5km^2 in the low-lying land along the dykes of the Yellow River, which is a typical area in Yucheng. Through joint efforts of experts of various disciplines from research institutes and local technicians and farmers, a series of advanced technologies have been introduced and developed. In order to comprehensively restore salt–alkaline land and improve agriculture productivity, the measures taken include:

1 An integrated irrigation system, combining wells, ditches and pipes. An open ditch system network was constructed to overcome waterlogging and alkalinization caused by five-yearly heavy floods, and three days' 166mm precipitation could be drained within a day after rainfall. A network of wells were constructed to provide irrigation and drainage; to reduce seepage and water pressure, and to increase groundwater resources and regulate the district groundwater table. Some other techniques were also set up for well irrigation engineering using pumps and pipes (underground water transporting pipes) and for irrigation (using plotted field engineering).

2 A series of irrigation measures. Water resources in this area are very scarce. It is, therefore, important to study the characteristics of salty water and techniques to

use it for irrigation to increase productivity, while preventing salinization and alkalinization in the ploughing layer (0–20cm).

3 Adjustment of patterns of cultivation. The plantation system in the plains area has changed from a one cotton crop system to wheat–cotton intercropping. High yield, high quality and disease- and salt-resistant varieties have been introduced. In the low waterlogged land a special model of platform field-ponds was developed, where high-yield crops/vegetables are planted on platform land and fish are introduced into the pond. With the help of this model, some 1,000,000 *mu* of low land, previously unproductive, has become high-yield land; while on sandy land afforestation has taken place.
4 Fertilization methods. Based on scientific research at the experimental station, a broader spectrum of fertilizers was adopted. There was an increase in the input of animal manure through development of animal husbandry. Some 3200kg of organic fertilizer, 12.8kg nitrogen and 6.2kg potassium chemical fertilizers were applied to each *mu*. Organic fertilizers, phosphorus and 20 per cent nitrogen were used as the basis. Phosphorus is no longer applied by hand but directly into the cotton ridges. During the growing period, 30 per cent nitrogen in the bud growth stage and 50 per cent in the flowering stage were added. It was estimated that the wheat–cotton intercropping system can yield 34kg of ginned cotton and 107.5kg of wheat per *mu*, or 40 per cent more as compared with monocropped cotton.

4. Combination of demonstration with dissemination

Based on successful scientific research at the experimental station, one demonstration area covering two townships with an area of 213,000 *mu* was established. The government mobilized the people in this complex engineering project, and more than 1.400 million m^3 of earth were dug in the process of construction in 175 sites. The heavy work is usually done by machines and the delicate work by hand. At the height of construction, 12,000 labourers and 60 big machines were employed at the construction sites. Funds were raised for construction from various channels, including investment from the government at different levels, collective investment by the farmers, and loans from banks. This open policy and encouraging perspectives of the region attracted more than 20 big enterprises, institutions and foreign businessmen to invest and rent lands for development, thus ensuring the successful implementation of the programme. Different patterns of IFS were developed at various scales in accordance with different physio-geographical conditions. Some of them provided immediate returns, even in the same year as construction. A consultation group comprised of a number of experts, practitioners and decision makers was organized to provide guidance for the eco-county construction. A series of carefully selected demonstration sites with specific priorities have also been established.

Case study II: Eco-county construction in Dazu

Background

Dazu County is located in the south-eastern part of Sichuan Province. It covers an area of 1390km^2, of which 6.9 per cent is mountains, 55.7 per cent is low hills and 37.4 per cent is medium hills. The population of the county is 890,000, 90 per cent live in rural areas and provide a labour force of about 404,000. The climate is subtropical monsoon, with an annual accumulation temperature (>10°) of 63–66°C, annual precipitation is 1006mm. The arable land of the county totals 680,000 *mu* with an average per capita of 0.85 *mu*. The soil is predominated by purple soil, which is relatively fertile and suitable for cultivation of different kinds of crops. However, due to a soaring population and irrational use of natural resources, the development of the county has fallen into a vicious circle.

In the early 1980s, an integrated survey for diagnosis and design of an eco-county was carried out. It was discovered that a series of disasters dominated the area: degradation of forest resources; increased soil erosion; degradation of soil fertility; worsening of local climate; shortage of rural energy; and poor economic development. Based on this situation and agroecological principles, the county government established a general framework and concrete measures for construction of an eco-county. In order to implement the development plan, the following measures were thought essential (Figure 18.7): (1) a leading group and special

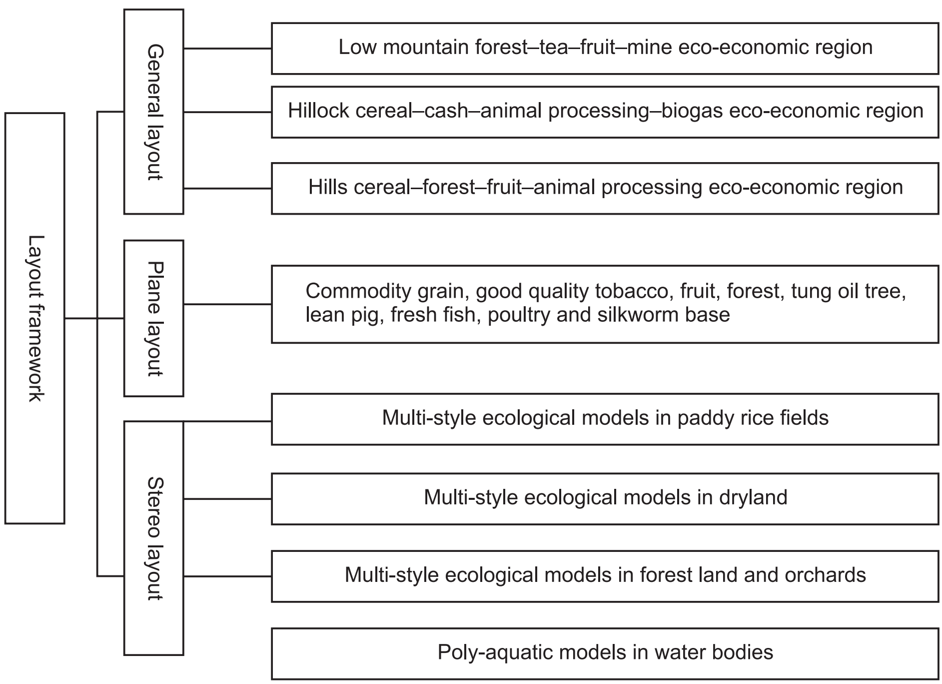


Figure 18.7 *The layout framework for Dazu ecoagriculture construction*

working office were established; (2) experimental sites were selected according to area and on the basis of scientific, technical and related decision making; (3) improving the plan and putting it into effect as a general development plan; (4) mobilizing farmers' participation and creating different ecoagricultural models suitable for prevailing conditions; (5) monitoring the development process and spreading successful experiences; and (6) signing contracts between governments, technicians and farmers.

After nine years' of construction and development in this county, forest coverage has risen, eco-environmental conditions have improved, economic growth has accelerated, and the county has become a model in ecoagricultural construction in China.

Major models of ecoagriculture

In order to use local natural resources and improve ecological and economic development, many ecoagricultural models have been created and practised: paddy rice, dryland forest, orchard, and pond/reservoir constitute the major types and there are many extensive models developed for different natural and social conditions.

1. Paddy rice–fish model

In the total area of 480,000 *mu* of cultivated fields, 160,000 *mu* have been developed in this model as: rice–mulberry–fish, rice–rice–fish, and rice–duck–fish models, occupying about 70,000, 12,000 and 1000 *mu*, respectively (Figures 18.8, 18.9 and 18.10).

2. Paddy rice-vegetables-vegetables/strawberries model

At present, this model occupies about 2000 *mu* of crop fields. It can create relatively high profits but inclusion of fresh strawberries means that it is only suitable for areas with convenient transportation and irrigation, close to markets (Figure 18.11).

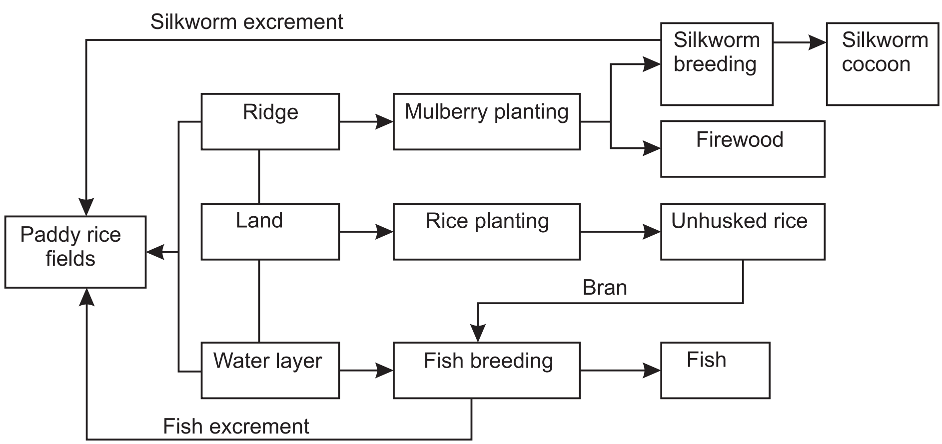


Figure 18.8 *The model for a rice–mulberry–fish ecosystem*

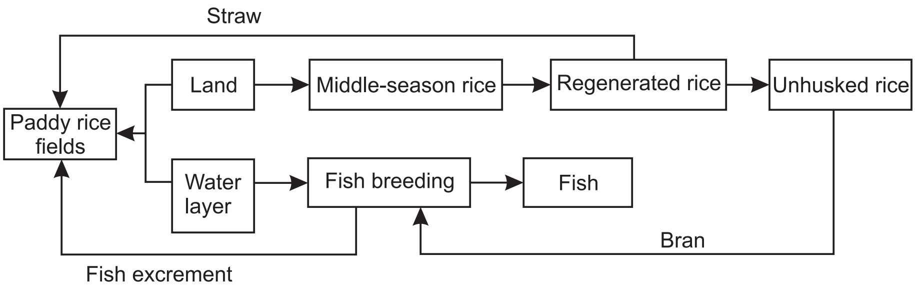


Figure 18.9 *The model for a rice–rice–fish ecosystem*

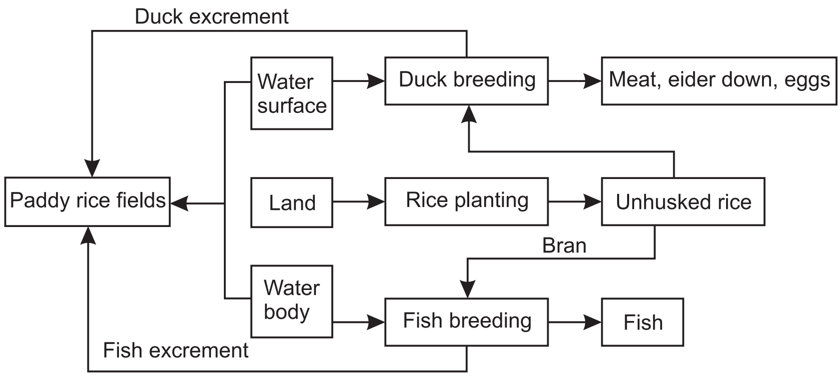


Figure 18.10 *The model for a rice–duck–fish ecosystem*

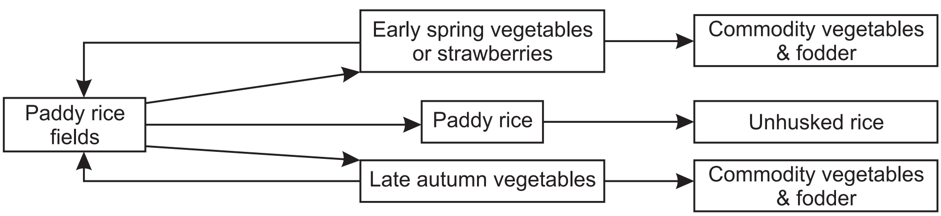


Figure 18.11 *The model for a rice–vegetable–vegetable/strawberry ecosystem*

3. Planting–breeding–biogas model

This model includes agriculture, animal husbandry and production of biogas and is a key link and the most popular throughout China, including Dazu.

Benefits analysis

In the process of ecoagriculture construction, remarkable ecological, economic and social benefits have been achieved by means of integration of economic development with environment protection, i.e. by stabilizing food production, adjusting ecological structure, protecting the environment and increasing income.

Ecological benefits

Through the construction of an ecoagriculture county, forest coverage was raised from 5.7 per cent in 1983 to 19.6 per cent in 1993 and, thus, atmospheric quality was also greatly ameliorated. Soil erosion was controlled, sources of drinking water were managed and improved, and agriculturally disastrous weather was decreased. In low mountain areas, 100,000 *mu* of bamboo entered the stage of canopy closure, 10 million plants of tung oil tree in the middle and remote mountains began to produce oil, and about 50,000 *mu* of orchard and 100 million mulberry trees are having positive effects on the environment.

Economic benefits

Through a nine-year construction period from 1984 to 1993, great progress in the agroeconomy of Dazu County has been made. The financial income was increased from 180.4 million *yuan* RMB in 1983 to 631.4 million *yuan* in 1993. Local financial input to agriculture was also enhanced from 1.59 million *yuan* in 1983 to 4.24 million *yuan* in 1993. The total income from the countryside reached 1.4 billion *yuan*, and was raised as much as 5.7 times. In 1993, the total production of food was 455 million kg, an increase of 22.7 per cent. In 1993, 3.988 million tons of fish was caught, which was 2.7 times that of 1983. As regards fruit production, this were 8.198 million kg or 2.7 times more than in 1983. The output of tung tree oil shot up to 2 million kg, 9.7 times more than in 1983.

Social benefits

Dazu was awarded the honour of Advance Unit of Agroenvironmental Protection by the Ministry of Agriculture, and was one of the approved 51 ecoagriculture counties. Many organizations and people, including many professors, specialists and students from over ten countries, showed their appreciation for these achievements. In addition, the construction of an ecoagriculture county accelerated the exploitation of natural resources and the development of sectors other than agriculture. Consciousness of environmental protection was further strengthened so that the degree of scientific decision making in agriculture was improved.

Perspectives

Based on the experiences gained in the pilot counties, the different models should be developed and implemented in accordance with various physical and economic conditions. We have summarized some of the main factors that need to be considered in further construction of eco-counties in all areas of China (Li et al, 1994).

1. Eastern coast region

This region includes the central eastern part of the Liaoning, Beijing–Tianjin–Tanggu area, eastern Shandong, Jiangsu, Zhejiang, Fujian and the delta of the Pearl River basin. These are the most developed areas in China with good conditions for development of industry and agriculture. Conservation of land resources should be the first priority in this region. High-quality, high-efficiency and high-yield agriculture should be developed here. The linkage between rural and urban ecosystems should be strengthened. The input of chemical fertilizer should be limited and rational exploitation of marshland should be made in coastal areas.

2. Songnen Plain region

Located in north-eastern China, this region includes Heilongjiang, Jilin, the northern part of Liaoning and a small part of Inner Mongolia. It is one of the most important bases of commercial grain and economic crop (e.g. soybeans, sugar beet) production as well as timber and petroleum. In the central and southern part there is little wasteland for reclamation due to a long history of cultivation. Special attention should be paid to developing agroforestry systems to strengthen the commercial base. The northern part of the region was only exploited later and there is still potential for further reclamation. The area has expanses of marshland which require special attention during eco-county construction.

3. Loess Plateau region

The most distinguishing feature in northern China is the extensive distribution of loess and loess-like deposits. Such deposits are distributed widely through Shanxi, Shaan'xi and Gansu Provinces, to form the famous Loess Plateau. The most concentrated loess region is in the middle reaches of the Huanghe River. Lack of rain, high temperatures, low humidity and dry winds during the crop growing period greatly affect crop yields. In addition, soil erosion is a serious problem constraining development in this region. About 1600 million tons of silt are carried downstream by the Huanghe each year, of which 90 per cent comes from the Loess Plateau. With the silt, about 30 million tons of nitrogen, phosphorus and potassium are lost. The huge amount of sediment carried downstream silts up the river courses causing flooding. The main task for eco-county construction is to take measures to control soil erosion and prevent degradation of grassland while developing production. A water-saving agriculture system should be established in the course of eco-county construction.

4. Huang-Huai-Hai plain region

This region covers the Haihe River plain in the north, the Huanghe River basin in the central part, and the Huaihe River basin in the south. It is one of the most important grain and cotton producing areas in China, with double cropping in its southern part and three crops in two years in the northern part. Inadequate drainage, a high water table, arid climate and strong evapotranspiration have caused salinization and alkalization that have impeded development in the region. The main task for eco-county construction is integrated manipulation of drought, floods, salinization and alkalization through effective utilization of water resources, rational construction of irrigation and drainage; effective use of straw and residues of crops, as well as the development of multi-layer and multi-component agroanimal husbandry systems.

5. South China red soil hills and low-mountains region

This area comprises the southern part of the subtropical zone and the lower reaches of the Changjiang River basin, Hunan, Jiangxi, Zhejiang, the northern part of Zhejiang and southern part of Hubei and Anhui Provinces. The organic matter in soil decomposes and leaches out rapidly. So, in spite of the nutrients accumulating quickly in the red earth, it contains only a small amount of organic matter with a high degree of acidity. It has weak water and fertility preservation capacity and is apt to be washed away or dried out. The main task for construction of an eco-county is to develop comprehensive models combining various sectors in order to fully use the natural resources and, at the same time, protect soil from erosion, and mitigate environmental degradation.

6. South-west China region

This region comprises the southeast of the Qinghai-Tibetan Plateau, west of the Guizhou Plateau, the Sichuan basin, almost all of Yunnan Province and the south-western part of Sichuan Province. It is influenced by the monsoon from the west and east, the weather is warm and clear in winter with heavy rainfall in summer. The main task for eco-county development is to raise the efficiency of water and land resources through the development of IFS. Special attention should be paid to introducing high-value cash crops and strengthening the linkage between agriculture and the processing industry so as to increase the value of commercial products.

7. North-western region

This consists of the Xinjiang Autonomous Region, the western part of the Inner Mongolia Autonomous Region, the Gansu Corridor, the Qilian Mountains and the Chaidamu Basin in Qinghai Province. Located in the central part of the Asian continent, this region receives little precipitation of uneven distribution. For construction of an eco-county, the first priority should be construction of irrigation systems and development of water-saving agriculture. Overall allocation and different combinations of cereal crops, afforestation and grass-planting are particularly important. Appropriate measures to fix sand dunes and control salinity should be incorporated.

8. South China tropical region

This region encircles the south of China, i.e. the southern part of Guangdong, the Guangxi plateau and the Tibetan Autonomous Region on the mainland, the island of Haina and part of Taiwan. With its high temperatures, abundant rain, and vast expanse of plains and hills, this region is an ideal environment for the development of tropical cash crops. But there are some unfavourable climatic factors for the development of such crops, including occasional low temperatures in winter, seasonal dry spells and strong winds. These can be prevented or alleviated to a certain extent by artificial measures. Protecting the environment, conserving land resource and developing IFS using a combination of agriculture, forestry, aquaculture and animal husbandry, are the goals of eco-county construction.

9. Qinghai–Tibetan Plateau region
The Qinghai–Tibetan Plateau is the highest in the world and covers the whole Tibetan Autonomous Region, most of Qinghai Province, the western part of Sichuan Province, north-western part of Yunnan Province, south-western area of Gansu Province and the southern border area of Xinjiang Autonomous Region. This region is characterized by its altitude, vastness, diversity and fragility. However, economic development is somewhat backward. The general aims for construction of an eco-county are to develop the regional economy by reforming the current crop-oriented cultivation to a three-dimensional economy by expanding the proportion of animal husbandry and forestry while strengthening nature conservation.

Construction of Shelterbelt Systems

China is a country with fragile ecosystems and suffers various and frequent disasters: north and north-western China is poor in natural resources and suffers frequent natural disasters such as floods, droughts, wind storms and soil erosion, which have caused tremendous threats and damage to agricultural production. In order to prevent and mitigate damage caused by disasters and improve agricultural production, the Chinese government has undertaken macro-scale shelterbelt construction in north-east and north-west China, the upper and middle reaches of the Yangtze River basin, the coastal zone and the plain region, together comprising the four biggest ecological engineering projects in China.

'Three North' forest protection engineering

Introduction
'Three North' includes the north-western, north and north-eastern region of China. This area is characterized by an arid or semi-arid climate. The 'Three North' region is not only abundant in natural resources but also rich in national heritage, with a long history. According to historical records, the region was once covered with dense forests, fertile grasslands and farmlands but, due to the wars of successive dynasties and other reasons, the ecological environment deteriorated year after year, causing serious sandstorms and soil erosion. Agriculture production and

animal husbandry were adversely affected and people lived in poverty due to lack of fuel, fodder, fertilizer and timber. It became known as a region with the most harsh environment with the most backward economic conditions in the country.

Forest resources and their distribution are influenced by the local environment which affect agriculture, livestock production and economic condition of the society. The Chinese Government has given priority to conservation and development of forest resources. Before 1977, the natural forest area in the 'Three North' region was only 16,947,000ha, of which scrub made up 42.6 per cent. The natural forests were distributed in hilly and mountainous areas of the south-east area of the 'Three North' region, and the medium and high mountains in the west, beyond the 400mm isohyet including the Tianshan Mountains, Aertai Mountains and Qilian Mountains. In the vast desert and semi-desert area, very little scattered natural secondary forest is present, with trees and shrubs such as *Populus euphratica*, *Haloxylon ammodendron* and *Tamarix chinesis*. The average forest cover of the three provinces was only 1.1–2.2 per cent. Serious destruction of natural resources has resulted in degradation. Drought frequency increased from an average of once in 17 years in the Qing Dynasty (1664–1800) to once every 1.5 years during the period 1950–1975.

The 'Three North' region is an important area for agricultural and livestock production in China, with rich solar energy resources. The annual accumulated day temperature, with daily temperature above 10°C amounts to 1500–4500°C. The annual frost-free period is 100–180 days. The annual average temperature gradually decreases from south to north and is between 12.1°C and –2.2°C. The north-western part of the region, covering 58 per cent of the total land, belongs to the arid climate zone, with an annual precipitation under 250mm. The south-eastern part of the region is in the semi-humid zone with an annual precipitation of 400–600mm. Between them, accounting for 10 per cent of the total land, is the semi-arid zone, with 250–400mm annual rainfall. Most of the rainfall is concentrated in summer, and only 10–15 per cent of rainfall is in spring (Table 18.14).

The construction of 'Three North' shelterbelt

In order to improve the natural environment and social conditions of people of the region and to speed up the development of agriculture, forestry and animal husbandry, the Chinese Government decided to build a protective forest system in the region seriously affected by drought, wind, snow storms and soil erosion. This came to be known as the 'Three North Protection System' and has been listed as a key project in the country's economic construction.

Guided by the theory of IFS, the 'Three North' shelterbelt system is designed to cover a vast area from 73°30' to 127°50' east and 33°20' to 49°48' north. It starts in Binxin County, Heilongjiang Province in the east to the Uzbel Pass, Xinjiang Autonomous Region in the west; and from the country's border with Russia in the north to Tianjing, the Fenhe, Weihe, the lower reaches of the Taohe River, the Burhanda and the Kunlun Mountains in the south, which includes 645 counties in 13 provinces, municipalities and autonomous regions, and covers an area of

Table 18.14 *Land distribution of 'Three North' region*

Areas	*Farmland*	*Forestland*	*Grassland*	*Others*
North-eastern China	22.9	16.5	45.4	15.2
Inner Mongolia and Xinjiang	2.5	3.2	38.4	55.9
Loess Plateau	29.9	18.5	35.7	15.9
Northern China	26.1	25.3	29.0	19.6

1,600,000km^2. Afforestation and shrub-grass cultivation will be carried out in a total area of 20,000,000ha. This programme is to be executed in three phases: first, scheduled from 1989 to 2000, incorporating 12,100,000ha of greening areas; second (2001–2010), 6,000,000ha are to be afforested; and the third (2010–2050) is expected to add another 1,900,000ha forest–grass–shrub plantation. On completion of the three phases of the programme, the forest–grass–grass cover should be 45 per cent in 2050, from 20 per cent in 1988. Farmland and pastures will be protected by shelterbelts; water run-off and soil erosion in the Loess Plateau will be brought under control; and the problem of firewood shortage will be basically solved. All these will lead to a great improvement in the economy and the standard of living of the local people.

As in most of the 'Three North' area, the shortage of water so seriously hinders tree survival and growth that the key to successful afforestation lies in meeting the desperate need for water. During the implementation of the programme, efforts were centred around fighting drought, as well as soil and water conservation. Technical designs were drawn up in the light of local conditions, e.g. planting the species best suited to the site, integration of trees, shrubs and grasses. Due attention is given to avoid monocultures which may invite plant diseases and insect pests. On the Loess Plateau, where soil erosion is extreme, preference is given to drought-resistant shrubs, conifers and broad-leaved trees such as little-leaf pea-shrub (*Caragana microphylla*), common seabuckthorn (*Hippophae rhamnoides*), wild peach (*Persica davidiana*), oriental arbor-vitae (*Biota orientalis*), Chinese pine (*Pinus tabulaeformis*) and black locust (*Robinia pseudoacacia*). In sandy, wind-blown areas, in addition to using of drought-tolerant species, an emphasis is put on shrub species most resistant to scouring sand, like sacsaoul (*Holoxylon ammodendron*), *Hedysarum scoparium*, *Hedysarum mongolicum* and *Callionum mongolicum*. In places with relatively favourable water conditions, quick-growing species of a higher quality are planted, e.g. Scots pine, poplar and narrow-leaved oleander (*Elaeagnus angustifolia*). In planting and maintenance, stress is placed on technical measures for fighting drought, from site preparation before the rainy season, water conservation and soil moisture preservation, to careful planting with strong seedlings and intensive management (Table 18.15).

Establishment of shrub plantation is possible in most of the area but is particularly suitable for arid and semi-arid lands. The success rate of shrubs is often twice or three times that of trees. Increase in forest cover through clothing the

Table 18.15 *Main species used for reafforestation in the Deng kou Experimental Bureau*

Scientific name	*Common name*	*Uses and features*
TREES		
Leguminosae		
Caragana arborescens (Lam.)	Pea tree	Indigenous
Elaeagnaceae		
Elaeagnus angustifolia (L.)	Russian olive or narrow-leaved marsh willow	Indigenous
Pinaceae		
Pinus sylvestris (L.) var. *mongolica* (Litv.)	Mongolian Scots pine	Indigenous
Pinus tabulaeformis (Carr.)	Table pine, Chinese pine, Flat topped pine	Indigenous to more southern areas of China
Salicaceae		
Populus bolleana (Lauche)	Xinjiang poplar	Used widely in S. America for shelterbelts and in hybridization, indigenous
Populus euphratica (Oliver) (syn. *Populus diversifolia*)	Diverse-leaved poplar	Indigenous, tolerant of heat and salinity with a large natural range
Populus nigra (L.) var. *thevestina* (Dode)	Grey bark poplar	Fairly drought tolerant, indigenous
Populus simonii (Carr.)	Weeping poplar	Largely ornamental but widely planted in early shelterbelts in China, indigenous
Salix matsudana (Koidz) var. *pendula* (Schneid.)	Pendulous willow	Produces fodder for livestock, indigenous
Salix matsudana (Koidz) cv. *Tortuosa* (Vilmorin)	Contorted willow	Ornamental, indigenous
Salix mongolica (Suizev)	Mongolian willow	Indigenous
Tamaricaceae		
Tamarix chinensis (Lour.)	Branchy tamarix	Deciduous, indigenous
Ulmaceae		
Ulmus pumila (L.)	Siberian elm	Indigenous
Sapindanceae		
Xanthoceras sorbifolia	Yellow-horntree	Deciduous, edible nuts and high-grade oil for cooking and machinery use, indigenous
SHRUBS and SUB-SHRUBS		
Leguminosae		
Ammopiptanthus mongolicus (S.H.Cheng)	Mongolian ammopiptanthus	Indigenous

Table 18.15 *(continued)*

Scientific name	*Common name*	*Uses and features*
Amorpha fruticosa (L.)	Shrubby false indigo	Deciduous, SE US
Astragalus adsurgens (Pall.)	Milk-vetch	Perennial, deep rooted, prostrate shrub, found on dry stony or gravel slopes and bogs, indigenous
Caragana korshinskii (Kom.)	Korshink pea shrub	Indigenous
Caragana microphylla (Lam.)	Little-leaved pea shrub	Indigenous
Halimodendron halodendron (Voss.)	Saltbush	Very salt tolerant, indigenous
Hedysarum mongolicum (Turcz.)	Mongolian sweet vetch	Suitable for aerial seeding, indigenous
Hedysarum scoparium (Fisch et May)	Slender branch sweet vetch	Suitable for aerial seeding, produces fodder for livestock, indigenous
Lespedeza bicolor (Turez)	Shrub lespedeza, bush clover	Deciduous, indigenous
Compositae		
Artemisia sphaerocephala (Krasch)	Ordos wormwood	Suitable for aerial seeding, indigenous
Artemisia sphaerocephala	Roundhead wormwood	Drought tolerant, suitable for aerial seeding, indigenous
Polygonaceae		
Atraphaxis bracteat	Saltbush	Very drought tolerant, deciduous, indigenous to nearby parts of Mongolia
Caligonum mongolicum (Turcz.)	Mongolian broom	Very drought tolerant, indigenous
Chenopodiaceae		
Haloxylon ammodendron	Saxoul (C.A. May)	Xerophytic pioneer shrub. Uses include fuel, fodder timber for building and roots for medicine
Elaeagnaceae		
Hippophae rhamnoides (L.)	Buckthorn	Deciduous, indigenous
Zygophyllaceae		
Nitraria tangutorum (Bobrov.)	Edible-fruited nitraria	Indigenous
Zygophyllum xanthoxylon (Maxim.)	Common beancaper	Edible buds, indigenous
Tamaricaceae		
Reaumuria soongarica (Maxim.)	Songory reaumuria, Songory tamarix	Indigenous

mountains will lead to great development of the entire region because it is labour-saving and less costly, and good results can be obtained in the short term. With adequate rainfall (no less than 200mm/year) and careful management, shrubs and some scattered trees provide pleasing views no more than three to five years from planting. Aerial seeding is carried out in some areas with sparse populations. Positive experiences of successful aerial seeding of shrub species has been gained in some places where annual precipitation is limited to 200mm.

The funds required for execution of the programme were raised from all possible sources. Private contributions in the form of investment of workdays on an individual or group basis were encouraged. Investment from collectives was taken from the gross revenue of various sectors of agriculture. The government also allocated funds totalling 267,000,000 *yuan* RMB over seven years. Another 9000 million *yuan* have been raised from other sources through either state or local channels. The funds from the state and collectives go mainly to planting and nursery activities. There are special plans to govern the use of the state funds which are put into key projects. Preference is given to those who have the best chance of success, and contracts are signed and payments are made by instalments, as requested. From time to time, assessment takes place when rewards and punishment are duly meted out. This approach functions well, guaranteeing proper use of funds and resources.

Accomplishments and effects

The joint efforts made by people of all nationalities have led to a total of 9,150,000ha being afforested, i.e. 831,800ha each year. In addition, 2,238,000ha of hills and mountains were also used to encourage the growth of forests and grasses, 23,000ha were air-seeded for forests, and 3 billion trees were planted in a scattered manner. In 11 years' of work remarkable ecological effects and considerable economic returns have been achieved through the development of farming, stock-raising and a diversified economy. In some areas of the region, sandstorms, water loss and soil erosion have been brought under control.

The forest shelterbelts have protected 11 million ha of farmland which were frequently hit by sandstorms and dry hot winds, and grain output has thus increased. For instance, the farmland shelterbelts built in the middle and western part have jointly formed a large system of forest networks. Obvious changes have taken place in regional microclimate. According to fixed spot observations made by the Jilin Institute of Forestry Survey and Planning, wind speed was reduced by 23.7 per cent on average; air temperature was raised by 0.63°C; soil surface temperature increased by 3°C; evaporation was reduced by an average of 15.2 per cent; soil water content increased by 18.6 per cent; and relative humidity by 12.6 per cent. About 40 per cent of the planted trees in the shelter belt networks have matured. This has alleviated the shortage of timber, fuelwood, fodder and fertilizer.

Grassland of more than 8,800,000ha has been established in desert and semi-desert areas of the region, controlling soil desertification, salinization and grassland degradation, and grass output has increased by over 20 per cent. In Maowusu and Holqin deserts forest coverage has gone up from 7 per cent and 10 per cent to 16.1 per cent and 18.8 per cent, respectively, since the project started. The ecological environment in the two areas has fundamentally improved.

In the Xishui He River valley and Weibei Plateau of Shanxi Province, forest coverage has considerably increased. Water loss and soil erosion have been brought under effective control with quite remarkable economic effect. Over 730,000ha of fuelwood forest produced three million tons of fuelwood per year which, combined with other energy resources, has solved the fuel problem for some five million households in the countryside. The area of economic forest has increased from 826,000 to 1,440,000ha which produced 2,750,000kg of dried and fresh fruits. The forest coverage of 12 cities and counties situated in the upper reaches of the Yellow River in Gansu Province increased from 8.7 per cent in 1977 to 12.3 per cent, and erosion-control area cover more than 300,000ha. In Shanxi Province three main sand-control forest belts have been established along the Great Wall, in the border area with Inner Mongolia and the foothills of the Baiyu Mountains.

Since the beginning of the project in 1978, the state and local authorities have invested 2420 million *yuan* RMB, and a total of 1050 million man-days have been spent by the people and local army units. Outstanding accomplishments have been achieved and the results are remarkable. As far as the entire project is concerned, this is just the first step of a 'long march', but it is firmly believed that this great IFS programme, which will benefit both our and future generations, can be brought to a successful completion under the leadership of the Chinese Government.

Shelterbelt systems in the middle and upper reaches of the Yangtze River Basin

Introduction

The Yangtze River (Changjiang) is the longest river in China, with the widest drainage area and the largest water flow. It originates from the Qinghai–Tibetan Plateau and flows eastward across Xizhang, Qinghai, Yunnan, Sichuan, Hubei, Hunan, Jiangxi, Anhui and Jiangsu Provinces/Autonomous Regions and Shanghai Municipality and enters the Pacific Ocean. The Yangtze River can be divided into three main parts, in accordance with physio-geographical conditions: the upper reaches (from Zhimenda of Qinghai Province to Yichang of Hubei Province), the middle reaches (from Yichang to Hukou of Hubei Province), and the lower reaches (from Hukou to the mouth at Shanghai) (Ren Mei'e et al, 1985).

The upper reaches of the Yangtze River lie on the Qinghai–Tibetan Plateau, with an elevation of 4000–5000masl. In the eastern margin of the Qinghai–Tibetan Plateau, all mountain ranges turn south-east or directly north–south, forming the famous Hengduan Mountain system with deep gorges cutting the upper reaches of the Yangtze River. The region which extends from the outer rim of the Qinghai–Tibetan Plateau, eastward to the Wushan Mountains, is mainly

Table 18.16 *The basic hydrological features in different sections of the Yangtze River*

Section	*Upper reaches*	*Middle reaches*	*Lower reaches*	*Total*
Length (km)	4529	927	844	6300
(%)	72.0	14.7	13.3	100
Drainage area (km^2)	100.55	67.74	12.56	180.85
(%)	55.6	37.6	6.8	100
Annual discharge (10^8m^3)	4543	4636	615	9794
(%)	46.4	47.3	6.3	100

composed of plateau and basins with elevations of 1000–2000m. Eastward from that line and extending to the mouth of the Yangtze River is the third great step. In the lower Yangtze River basin, the third step staircase, there are extensive plains largely below 50m. This region is famous for grain production. The Yangtze River has a vast drainage area of $1.8 \times 10^6 km^2$ and a particularly heavy annual run-off of $9.79 \times 10^{11} m^3$, accounting for 37.2 per cent of the national total. In terms of average flow, the river has a water resources reserve of 2.3×10^8kw, or 42.5 per cent that of the whole country. The average annual flow of the Yangtze River accounts for over 30,000m^3/s, or 17 times that of the Huanghe River. Table 18.16 shows the basic features of different sections of the river.

In order to relieve the Yangtze River flood problem, large-scale hydrological works have been done since 1949. Dykes along its main stream and its main tributaries have been repaired, raised or strengthened. The Jingjiang flood diversion project, the Hanjiang flood diversion project and other flood-storage projects have been built along its middle reaches, where the area is often hit by unusual floods. Many lakes have been dredged, and this has increased the capability of the Yangtze River to prevent flooding. At the same time, more than 40,000 small reservoirs for irrigation, and over 500 big and medium-sized reservoirs for multi-purpose utilization have been built. Currently, the Three Gorges Project, attracting worldwide attention, is underway, which will play an important role in preventing natural disasters and providing the electric power for economic construction and development of the Yangtze River basin.

The climate of the middle and upper reaches of the Yangtze River basins is characterized by a vertical differentiation of climatic zones (Table 18.17). However, most of the areas located between 2000–3000m belong to a subtropical zone with warm winters, cool summers and spring-like weather for all four seasons. Although climatically the region does not have marked contrasts in seasons, it does have notable differences in dry and wet weather. Generally, it is dry from November to April and wet from May to October.

The forest vegetation in different sections of the Yangtze Basin varies significantly. In the upper reaches of the Yangtze River, forest vegetation in some areas has maintained its natural structure and the latitudinal differentiation of the vegetation

Table 18.17 *Climatic conditions of the major cities along the Yangtze River*

City	*Mean annual temperature (°C)*	*Annual precipitation (mm)*
Yushu	2.9	480.5
Changdu	7.5	477.7
Huili	15.1	1130.9
Yibin	18.0	1177.3
Chongqing	18.3	1079.4
Yueyang	17.0	1302.4
Yichang	16.8	1164.1
Wuhan	16.3	1204.5
Jiujiang	17.0	1412.3
Anqing	16.5	1389.2
Wuhu	16.0	1169.8
Nanjing	15.3	1031.3
Shanghai	15.7	1123.7

are distinct, though most areas have suffered human disturbances. On the humid slopes, less than 2500masl, the original forest vegetation features subtropical mixed evergreen–deciduous broadleaf forests. The dominant species are in the genera *Quercus*, *Alnus*, *Lithocarpus*, *Liquidambar*, *Populus*, *Castanopsis* and *Cyclobalanopsis*. Most of these trees are somewhat cold-resistant evergreens, mixed with some temperate deciduous broadleaf trees. The forests have a complex form with a three-layer structure. The first layer consists of deciduous broadleaf trees, while in the second and third layers are evergreen broadleaf trees. On the forest floor the bamboo, *Sinarundinaria chungii*, grows. The deciduous broadleaf trees are mainly of the beech family, which reflects the extreme humidity of the local environment. The representative species of evergreen broadleaf trees are *Cyclobalanopsis glauca* of the beech family, *Phoebe bourpei* of the laurel family, and *Schima superba* of the tea family. Between 2500m to 3000m there are mixed coniferous broad-leaved forests. From 3000m to 4000m and even higher is the sub-alpine forest belt, dominated by species of spruce and fir. Alpine scrub, meadows and nival vegetation can be found in areas higher than 4000m. In the Hengduan Mountains are valleys with less precipitation, where the so-called dry and hot valley vegetation occurs.

In the middle reaches of the Yangtze River the zonal vegetation is mixed evergreen and deciduous broad-leaved forests, growing on yellowish-brown soil. The natural forests are mainly distributed on mountains and hills. The forests are green all year round and contain an arbour layer, a shrub layer and a herbaceous layer. The trees are mainly in the genera *Cyclobalanopsis* and *Castanopsis* of the beech family and associated deciduous trees of beech, walnut and maple. Among the coniferous trees, masson pine (*Pinus massoniana*) and Chinese fir (*Cunninghamia lanceolata*) are dominant below 600–800m. Above this, Huangshan pine (*Pinus hwangshanensis*) grows. On the low mountains and hills cash tree crops such as chestnut, tung oil trees, Moso bamboo (*Phyllostachys pubescens*), Chinese sapium, tea trees, lacquer trees and citrus are cultivated. But warm-temperature fruit trees such as persimmons, Chinese chestnuts, pears, peaches and apricots can also be grown in this region. During recent decades many species have been used for afforestation. Besides the endemic species such as Chinese fir, masson pine and *Metasequoia glyptostroboides*, moso bamboo, *Quercus accutissima*, *Cinnamomum camphora*, *Castanopsis fargessi* and *Sassafras tzumu*, as well as many other fast-growing species such as *Pinus elliottii*, *Pinus taeda*, *Chamaecyperis*, spp. and *Eucalyptus* spp. have been introduced for afforestation.

In the lower reaches of the Yangtze River are vast low-lying plains. The zonal vegetation is mixed evergreen and deciduous broad-leaved forest, and the zonal soil type is yellowish-brown soil, restricted to low mountains and hills. The extensive plains have been turned into cultivated vegetation and paddy soil. Even on low mountains and hills, original mixed forests were mostly destroyed and have been substituted by secondary growth of shrubs and grasses, and partly planted with masson pine and other economically valuable tree crops, such as tea and fruit trees. The great contrast between the intensively used and densely populated plains and the rather extensively used and sparsely populated slope lands is an outstanding feature of the region.

Main environmental problems

Degradation of forest

The long history of exploitation, increasing population pressure, the demand for timber and fuelwood, inadequate forest management, illegal use of marginal land, and poor economic development of the region, have led to declining forest cover and timber stocks. For instance, in Sichuan Province, forest cover decreased from 20 per cent in the 1950s to 13 per cent in the 1980s. While forest cover in the Sichuan Basin accounts for only 4 per cent. A similar situation is found in other provinces along the river; in Jiangsu, Anhui and Guizhou Provinces forest cover is only 8 per cent, 13.5 per cent and 15.1 per cent, respectively. So, the water conservation and regulatory role of forests in the Yangtze River has decreased significantly.

Degradation of forest quality has also occurred. Many forests in the region are being degraded into low-value, secondary forest through repeated human disturbance, low soil fertility and careless management. In the upper reaches of the Yangtze River there are over 600,000ha of low-value forest, most of them in the Jialing River area and accounting for 60 per cent of the total forest. Pine and cypress are the dominant species of low-value forests (Yang Yupo, 1993). It is an arduous task to improve the current situation of low-value forests and replace them by high-yield forests with effective environmental protection.

Table 18.18 *Variation of soil and water erosion areas*

Region	*1957*		*1987*		*Increasing*	
	Area (km²)	*Proportion (%)*	*Area (km²)*	*Proportion (%)*	*Area (km²)*	*(%)*
Total	363,790	20.2	739,376	41.0	375,586	103.2
Jiangsu	1850	3.8	6100	12.3	4250	229.0
Anhui	13,686	21.3	19,263	30.0	5577	40.7
Jiangxi	11,000	6.6	38,360	23.0	27,360	248.7
Hunan	55,880	27.6	56,640	27.9	760	1.4
Sichuan	93,380	16.1	382,000	67.3	288,620	309.1
Guizhou	12,816	11.3	35,300	31.2	22,484	175.4

Soil erosion

Soil erosion in the Yangtze River Basin is caused by both natural and man-made causes. The natural causes in the Yangtze River watershed include fragile mountain environments, high intensity, long duration rainfall, high stream density, steep stream gradients, mass movements, debris flows and landslides. The causes induced by human activities include deforestation, inappropriate land management practices, road construction in fragile lands, improper water collection, transportation and use of water. According to statistics, the total discharge of the Yangtze River reaches 5.02×10^8 tons per year, or 19.1 per cent of the national total. At present, the water flow of every tributary in the upper reaches is decreasing, but the content of silt is increasing. For example, in Sichuan Province, the average silt content of water flowing in the Three Gorges area was about 5.1×10^8 tons in the 1970s, and increased to 6.8×10^8 tons in the late 1980s. The general status of soil erosion in different provinces of the Yangtze River Basin is given in Table 18.18.

Since 1954 natural water bodies in the middle and upper reaches of the Yangtze River have declined by some 12,000km^2. For example, the surface area of Poyang Lake has decreased by 36 per cent. In the Dongting Lake area 166,000ha have been reclaimed for farming. Some 10,000ha of land in the Taihu Lake area were also turned into polders between 1969 and 1974. In the Jianghan Plain the number of lakes with a water surface area over 50ha has dropped by 40.36 per cent from the 1950s to the 1980s and the total water surface area shrank by 43.67 per cent (The National Conditions Investigation Group under the Chinese Academy of Sciences, 1992).

Construction of protective forests in the upper and middle reaches of the Yangtze River

In 1989 the state approved the 'Overall Plan for the Construction of the Protection Forest System in the Middle and Upper Reaches of the Yangtze River'. The objectives were not only to reduce water and soil loss, but also to improve the ecological environment for agriculture and to accelerate development of the economy in mountain areas. Under the guidelines of IFS, a multipurpose and comprehensive protective forest system was designed. This system integrates protective forest with cash crops, fuel wood, timber and other forest with specific purpose species. In the general plan of afforestation, arbour trees, shrubs and grass are combined. The coniferous and broad-leaved trees, deep-rooted and shallow-rooted plants, fast-growing and slow-growing plants, supplement each other to form an integrated system with a great variety of plant species and multiple layers (Investigation and Research Team of Sichuan Forestry Society, 1990). This is a huge forestry ecological engineering project, covering 13 provinces/autonomous regions, 645 counties, and with a total area of $4{,}06 \times 10^6$km^2. The total area for afforestation is about 20×10^7ha. It is proposed that the areas of afforestation will consist of 1.21×10^7ha between 1989 and 2000; 1.90×10^6ha between 2011 and 2050. After completion of the project, the forest coverage will be raised to 45 per cent.

The Yangtze River protective forest system may be divided into six eco-economic zones: the Jingsha River watershed on the western plateau of Yunnan and Sichuan Provinces, the Hanshui River watershed in the Qingling Range–Dabashan mountainous area, the Jialing River watershed in the Sichuan Basin, the Wujiang River watershed on the West Guizhou plateau, the Yangtze Trunk River watershed in mountainous areas of Sichuan and Hubei Provinces, and water systems of Dongting Lake and Poyang Lake in hilly areas of Hunan and Jiangxi Provinces.

In the upper reaches of the rivers running across high mountains in western Sichuan Province, north-western Yunnan Province and the highlands of the northern and south-western edges of the Sichuan Basin and Qinling–Dabashan Mountains, special protective forest systems for soil and water conservation, in combination with timber production forests, should be initiated. The forest of multiple purpose use, including soil conservation, fuelwood, economic and shelterbelt forest networks, should be established in hilly areas of the Sichuan Basin. A forest system made up of timber, economic, and soil and water conservation forests should be undertaken in the mountainous areas of the Wujiang watershed. In the Dongting and Poyang Lake region and the lower reaches of the Yangtze River, bank protective and economic forest networks are the key types for protective forest construction.

The distribution and layout of different kinds of forests should be based on the concrete conditions. Taking the hilly areas of the middle and upper reaches of the Yangtze River as an example, the general layout of its protective forest system is as follows: water and soil conserving forests on the top of the hills and on the slopes, economic forest belts serving to conserve soil and protect earth banks between farmland, and farmland protection forest networks between hills and in the valleys and plains. This arrangement provides step-like forest protective networks which run from hill tops to valley lands, intercepting water and conserving soil at different levels. This provides a spatial pattern of water and soil conserving forest in hilly areas which combines protective and productive functions in the agroforestry system.

In general, gentle slopes of less than 10° gradient and valleys where soil erosion is infrequent are suitable for growing food or cash crops. Slopes of 10–20° gradient are suitable for growing economic or cash forest. Accelerated development of cash forest plantations is absolutely necessary in order to mobilize participation to overcome difficulties due to shortage of funds for long-term silvicultural programmes in mountain areas. Economic forests are a special category which are mainly used for non-wood products such as fruits, edible oils, fibres, pharmaceuticals, resins, gums, waxes and many other raw materials for industrial and commercial purposes. In the subtropical area of the lower reaches of the Yangtze River the most widespread species with economic potential are tea oil trees (*Camellia oliefera*), tung tree (*Aleurites fordii*, *A. montana*, *Sapium sebiferum*), Chinese walnut (*Juglans regia*), Chinese chestnut (*Castanea mollissima*), lacquer tree (*Rhus verniciflorum*), star anise (*Illcium verum*), eucomia (*Eucomia umoides*), and citrus fruit groves (*Citrus reticulata*), *Litchi chinenses* and *Euphorbia longgan*. Slopes of more than 20° gradient and hills need tree or scrub species to conserve water and soil. The common species of timber used for soil protection are *Pinus massoniana*, *Pinus elliottii*, *Cunninghamia lanceolata*, *Quercus accutissima*, *Eucalyptus robusta*, *Sassafras tsumu*, *Robinia pseudoacacia*, *Ailanthus altissima*, *Albizzia julibrin* and *Paulownia fortunei*. In recent years, after overall planning and comprehensive improvement, a number of red earth areas that were low yielding in the past have changed dramatically.

In the Yangtze River Basin there are about 60 tree species, 20 shrub species and more than 30 herb species (not including those existing in silviculture environments) used for protective forest construction. Most of these species are indigenous, a few exotics suitable for these areas were also introduced, based on experience and observation in small-scale plots. Community structure and stand density determine forest function. They also affect ecological and economic benefits of the protective forest. Table 18.19 shows the major tree species for reforestation and their planting density in the Yangtze River Basin.

Effects of afforestation for environmental protection and regional development

1. Improving the environment

Seven years after the implementation of the Yangtze River Protective Forest Project, the environment of the Yangtze River Basin has been improved significantly. It is estimated that 2,707,500ha of multifunctional protective forest have been reforested during the Eighth Five Year Plan period in the upper reaches of the Yangtze River (Lu, 1996). The vegetation cover of the whole Yangtze River Basin has increased over 5 per cent. The proportion of protective forest and mixed forest has increased nearly 100 per cent. Most of the reforested woodland stands have closed and grown well. Shrub and herb layers of stands have developed rapidly. As a consequence, loss of water and soil has been primarily controlled and the area of soil degradation has been greatly reduced (Yang, 1993). In Xingguo County of Jiangxi Province, for example, the area of soil erosion was reduced from 160,000ha to 50,000ha and forest cover has increased 20.8 per cent, as compared with the 1980s. This previously well-known 'desert area of the southern Yangtze River' for water

Table 18.19 *Planting density of main tree species of protective forest in the Yangtze River Basin*

Species	*Single-storied forest*		*Multi-storied forest*	
	D (m)	*Stems/ha*	*D (m)*	*Stems/ha*
Cupressus funebris	1.2 × 1.2–1 × 1	6945–10,005	1.8 × 1.8–1 × 1.5	3090–6660
Pinus massoniana	1.5 × 1.5 × 1.5	4400–6660	1.5 × 3–1.5 × 2	2220–3330
Pinus armandii	1.5 × 1.5–1 × 1.5	4440–6660	1.5 × 3–1.5 × 2	2220–3330
Pinus elliottii	2 × 3–2 × 2	1665–2505		
Cunningham lanceolata	2 × 2–1.5 × 2	2505–4440		
Cryptomeria fortunei	2 × 2–1.5 × 2	2505–4440		
Metasequoia glyptostroboides	2 × 3–1.5 × 1.5 1.5 × 2–1 × 1.5	16,665–4440		
Larix kaempferi	1.5 × 2–1.5 × 1.5	3330–6660		
Quercus acutissima	2 × 3–2 × 2	3330–4440		
Q. variabilis	4 × 2–1.5 × 2	1665–2505	3 × 4–2 × 3	
Cinnamomun sp.	2 × 2–1.5 × 1.5	1245–3330		840–1665
Eucalyptus robusta	2.5 × 2.5–2 × 2	2505–4440		
Camptotheca acuminata	1.5 × 2–1.5 × 1.5		3 × 3–1.5 × 2	
Sassafras tsumu	2 × 2–1.5 × 1.5	1605–2505	3 × 4–1.5 × 3	1110–3330
Alnus cretnastogyne	4 × 4–3 × 3	3330–4440	5 × 5–3 × 5	825–6720
Melia toosendan	2 × 2–1.5 × 1.5	2505–4440		405–660
Populus sp.	1.5 × 1.5–1 × 1.5	630–1110	3 × 3–1.5 × 2.5	
Pterocarya stenoptera	1.5 × 2–1 × 1.5	3330–4440	2 × 3–1.5 × 2	1110–2685
Robinia pseudoacacia	2 × 2–1.5 × 1.5	3330–6660	3 × 3–1.5 × 2	1665–3330
Cladrastis wilsonii	3 × 4–2 × 3	4440–6660		1110–3330
Salix babylonica	2 × 2–1.5 × 1.5	2505–4440		
Paulownia fortunei	1.5 × 1–1.5 × 1.5	825–1665		
Gordonia acuminata	1.5 × 2–1.5 × 1.5	2490–4440	2 × 2–1.5 × 1.5	
Betula luminifera	2 × 3–1.5 × 2	4440–6660	2 × 3–1.5 × 2	2490–4440
Ailanthus altissima	2 × 2–1.5 × 1.5	3330–4440		1665–3330
Albizzia julibrissin	4 × 4–3 × 3	1665–3330	3 × 4–2 × 3	
Bischoaia javanica	2 × 3–1.5 × 1.5	2025–4400	6 × 6–4 × 5	
Ficus lacor	4 × 5–3 × 4	615–1110		270–495

Table 18.19 *(continued)*

Species	*Single-storied forest*		*Multi-storied forest*	
	D (m)	*Stems/ha*	*D (m)*	*Stems/ha*
Ligustrum lucidum	3 × 4–3 × 3	1665–4440		
Phyllostamus pubescens	7 × 7–5 × 5	495–825	4 × 5–4 × 4	
Sinocalamus affinis	4 × 4–3 × 3	825–1110		495–615
Juglans regia	4 × 5–3 × 3	195–390	6 × 6–4 × 5	
Aleurites fordii	8 × 6–6 × 7	615–1110	7 × 8–5 × 6	270–495
Castanea mollissima	6 × 7–5 × 6	495–825	10 × 10–8 × 9	180–330
Litchi chinensis	3 × 4–2.5 × 3	150–240	9 × 9–6 × 7	90–135
Euphorbia lorgan	1.5 × 1.5–0.8 × 0.8	240–330	4 × 5–3 × 4	120–240
Citrus reticulata	2 × 3–1.5 × 2	825–1335	2 × 3–1 × 2	495–825
Morus alba	2 × 2–1 × 1.5	440–15,630	4 × 5–3 × 3	1665–4995
Fraxinus chinensis	6 × 7–4 × 5	1665–3330		495–825
Trachycarpus fortunei	3 × 4–2 × 3	2205–6660		
Rhus pyrifolia	l × 1–0.5 × 0.5	204–495		
Camellia oleifera	1.5 × 1.5–1 × 1	825–1665		
Coriaria sinica, Maxim	2 × 2–1 × 1	10,005–19,995		
Amorpha fruticosa	1 × 1.5–0.8 × 1	4440–10,005		
Nerinus indicum	1 × 1–0.7 × 1	825–2130		
Rosa roxburghii	1 × 1–0.5 × 0.5	6660–13,245		
Miscanthus sinensis		10,005–14,280		
Saccharum spowtaneum		10,005–40,020		

and soil erosion has become a prosperous and green county (Li et al, 1994). Field observations from watershed management show that protective forests have good effects on water conservation, while improving soil structure and chemical properties (Tang and Guo, 1995; Xiang, 1996). In addition, the crown and understorey layer of protective forest are capable of intercepting precipitation, reducing flow speed of surface run-off, increasing soil penetrability and enhancing water and soil conserving capacity. The protective forests have played a key role in maintaining soil fertility and conserving water and soil.

2. Providing favourable conditions for rural development

On the basis of reforestation with protective forest systems and implementing the ecological benefits of these systems, a great number of forest production bases have been established. Considerable economic benefits have been gained in terms of timber, fuelwood and economic forest products, such as medicines, fruit and other non-wood products. During the National Eighth Five Year Plan, more than 600,000ha of economic forests were reforested, and some 8000 township-owned forest farms were established in the middle and upper reaches of the Yangtze River Basin. Small-scale orchards, gardens for cultivation of medicinal plants, tea gardens, mulberry woodlands and bamboo gardens are growing in the area. The forests have improved the environment and microclimate for agricultural development and have promoted development of green industry. The cash income from the forest has reached nearly one-quarter of the farmers' total income.

According to observations and research in the experimental sites distributed in different topographies it was found that, after execution of the project, the forest coverage has increased and the environment of the region has improved significantly. For example, forest coverage has increased from 17.6 per cent to 41.6 per cent in low mountain areas, from 8 per cent to 39.9 per cent in hilly areas and from 12.7 per cent to 24.7 per cent in low hilly areas. Soil erosion has dropped from 4000ton/ha to 2000ton/ha. Considerable economic benefits have also been gained in terms of timber, fuelwood and economic forest products. In Wangchanggou small watershed, Guangyuan City, 33,000 fruit trees have been grown with an expected annual fruit yield of 800,000–1,000,000 *yuan* RMB. In addition, the blend of forests and grasses in the area supplies sufficient grass to feed between 1000–2000 cattle per year. It is expected that, by the year 2000, adjusting the optimal ratio between agriculture and forestry will likely reach 0.70–0.75 : 0.25–0.30 in hilly areas, and 0.25–0.30 : 0.70–0.75 in mountainous areas. The structural ratio between protective, timber, economic and fuelwood forest will likely attain 0.40–0.50 : 0.25–0.30 : 0.20–0.25 : 0.05, respectively, in hilly areas. While in the mountainous region, the structural ratio of protection forest will reach 50–60 per cent, timber forest 30–40 per cent and economic forest 10–15 per cent.

Perspectives

Although afforestation in the Yangtze River Basin has made preliminary progress in the past several years, there are still many problems to be solved for improving its forestry.

1. Conservation and rational utilization of existing forests

The felling of existing forest must be well planned in both local and state-owned forests. The timber felled each year should not exceed the annual increase in timber volume. To take into account the long production cycle of forests, and to compensate for lost forest resources resulting from excessive cutting over a long period in the past, a fixed forest culture fee should be levied on the selling price for timber, bamboo and other forest products. Forest culture funds should be used mainly for preparing deforested land for production and for planting new forests. The forest department will conduct scientific research to increase the wood utilization rate and to discover potential uses for tree species that are currently not being used but which may have domestic or commercial potential. (Li Wenhua, 1993)

2. Afforestation and reforestation

To plant trees and afforest the country is a basic national policy. In order to fulfil the task effectively it is necessary to continue to carry out the construction of forest systems along the Yangtze River, and to establish timber production bases in the hilly regions. These areas have high precipitation, with good conditions for development of fast-growing trees in short rotation. In addition to afforestation organized by forestry organizations, a voluntary mass afforestation campaign is being encouraged. For example, according to a resolution of the People's Congress, all Chinese citizens above the age of 11, apart from the old, weak, sick and disabled, are obliged to plant three to five trees every year or provide an equivalent amount of labour by cultivating saplings, tending trees or other afforestation work as a condition of their permit. The locals have to carry out afforestation campaigns around 'four sides' (around houses, villages, roads and ditches). In addition to forest plantations, to assist natural regeneration, hillsides should be closed to facilitate reforestation and redevelopment of forest ecosystems. Aerial sowing is especially important in sparsely populated remote areas.

The department of forestry will undertake and encourage the development of agroforestry in the region in general, and in the middle and lower reaches of the Yangtze River Basin in particular, where population pressure is particularly acute and cultivated land is scarce. Research programmes should be conducted to identify the optimal planting and cropping patterns under various conditions in order to improve overall productivity and to determine ecological compatibility.

3. Rectifying the existing laws and management systems

These include: adjustment of the timber value in accordance with marketing requirements; establishment of a rational subsidy system for forest environmental protection; implementation of a low tax system for ecologically sound and environmental protection-oriented forestry management units and enterprises; establishment and improvement of a system of proper rights on exploitation; repayable use and transfer of forest resources; development of a forestry production insurance system; and accelerating multiple channel fundraising.

4. Improving nature reserve construction

A nature reserve is a legally confined area where various important ecosystems and their environment, endangered species and national historical relics are placed under protection and management. The Yangtze River Basin is characterized by its rich biodiversity, unique ecosystems and numerous endemic and endangered species. During the last decades many nature reserves have been established in this region, mostly located in forest areas. Although significant progress has been made in establishing nature reserves in the region, much work is still to be done in the future and it is important that every nature reserve should have a proper management plan and implement it *in situ*.

5. Scientific research

China will give special attention to forestry research by developing projects to solve the key problems of afforestation, and engage in research on seed multiplication, containerized saplings, vegetative propagation, high-yield tree saplings and dryland afforestation. A quota system and methods for increased forest utilization and regulation of forest reclamation will be established. China will take various measures to improve the maintenance of the ecological values of forests. It is important to establish forest inventory, monitoring and assessing systems for forestry. It is necessary to develop advanced forest utilization and exploitation techniques that minimize the impact on the environment, or have low pollution value, and work to develop and promote non-timber forest products. China will develop comprehensive prevention and control methods for pests and plant diseases, detection and prediction of forest fires, and will research and spread new fire prevention techniques.

6. Training and education

In order to mobilize the people's participation and improve forest management, an important goal will be to develop a forest public education system to make the value and multipurpose usage of forests known to the public. It is important to train forestry professionals and workers, with the emphasis placed on the young and women. China's Agenda 21 (The Editing Committee, 1994) states that China will set up demonstration project bases and training centres dedicated to the layout of shelterbelts and networks for fast-growing and high-yield forests. Model forest policies and management centres will be established and one prefecture from each province or autonomous region will be selected for setting up demonstration units. China will set up a national training centre for forest resource management and forestry administration. The afforestation engineering of the Yangtze River Basin is not only an ecological rehabilitation project, but also an economic reconstruction process. It closely relates to the long-term interests of people. Therefore, it is important to formulate a series of technical and economic policies for protective forest engineering.

7. Multi-channel fundraising

The local people have put their efforts into the afforestation campaign. However, for conducting such big engineering projects with long-term returns, fundamental funds are necessary. The people's enthusiasm should be encouraged by incentives from the government at various levels. The government has decided to increase investment in forestry from the current 0.14 per cent of GNP to 0.3–0.4 per cent by the year 2010. A multi-channel fundraising system should be encouraged.

8. International cooperation

China has signed several major conventions concerning protection of biodiversity and forest management. Cooperation will be in accordance with the mechanisms of relevant conventions and in accordance with national and local conditions, so as to share benefits and to obtain financial and technical assistance. China will continue to expand international, bilateral and multilateral cooperation, and wishes to enhance exchanges and cooperation in the fields of management, scientific research, technical development and technical transfer, and manpower training.

Forestry management in the Yangtze River Basin has not only attached great importance to regional development but also has an important influence on the environment and development of the country as a whole. It is our sincere hope that, with the efforts of the Chinese people and with international cooperation, forestry in the Yangtze River Basin will be developed successfully so that it can bring benefits to meet the needs of the present while not compromising the ability of future generations to meet their own needs.

Other shelterbelt systems

The coastal windbreak system

The coastline of mainland China is 18,000km long, and the coastal area includes 195 prefectures/cities/counties in 11 coastal provinces and autonomous regions, covering an area of 25.0 million ha, and involves a population about 100 million (Ministry of Forestry of the People's Republic of China, 1995b; Scientific and Technological Information Center of China, 1991). The coastal area is the major base for the resources of agriculture, forestry, animal husbandry, supplementary production and fishery. But natural disasters befall it frequently and bring unfavourable elements such as strong winds, sandstorms, high tides, droughts, waterlogging, soil salinization and soil erosion. In the 1950s, China had already started to establish a coastal windbreak system with a combined structure of belts, tracts and networks grouped together, mainly to break wind and to fix sand. Among these, the backbone forest belts, as a first line of defence, have a normal width of 100–200m, with a maximum width of 500m. They ran parallel to the coastline, or vertical to the direction of winds, shifting sands and sea waves. As tracts, belts of forests with a high density 4500–6000 plants/ha were established on sand dunes, sandy beaches, sand belts and along the sea coast to fix drifting sand, and their width was usually no less than that of the drifting sand belt. Since the early 1980s, the coastal windbreak has been gradually transformed into an eco-economic type. The shelter windbreak combined well with timber, economic and fuel forest, to provide a coastal windbreak system with multiple functions and high benefits. This gradually developed into a basis for economic forests oriented to forest trade and 6.8 million ha of shelterbelt has been planted, raising forest coverage to 27.2 per cent.

The farmland shelterbelt system in the plains

The farmland shelterbelt comprises the majority of China's shelterbelts. China's farmland regions include the Sanjiang Plain, the Songliao Plain, the Huanghuai Plain, the North China Plain, the plain in the middle and lower reaches of the Yangtze River and the Pearl River Delta. The total area is 113 million ha in these agricultural regions, covering 993 counties, and contains half of the national total population (Ministry of Forestry of the People's Republic of China, 1992, 1993, 1995a, 1995b). From the beginning of the 1960s, the afforestation campaign was centred on the greening of the plains, and a farmland forest network was established with a structure of 2–3 rows of trees along canals, irrigation ditches and by roadsides, in accordance with local conditions. So far, one-fifth of China's crop land has been incorporated under the shelterbelt network. Natural disasters have been effectively controlled, and the stress resistance capability of farmland has been significantly enhanced. China's farmland shelterbelts are developing into an integrated type of multiple purpose forest.

Recommendations and perspectives

In order to achieve long-term sustainability of shelterbelt systems in land use, technical and funding support is critical for its efficient management. The recommendations on technical support, according to different ecological and environmental conditions in various areas, require promotion of the use of high quality planting material, selection of sites for the appropriate species, prevention of forest pests and diseases, and establishment of multi-functional ecological forest systems with combinations of trees with bushes and grasses. Improvement in the composition of tree species and forest types in the shelterbelt systems are needed, increases in the percentage of economic forest and economic tree species should be implemented that will raise the direct value and bring into full play public initiatives for establishing and protecting shelterbelts. Shelterbelt management information and monitoring systems should be set up, as well as a shelterbelt research centre to train technical and operational personnel, speed up the application of research results, and extend nationwide the experience gained in conducting model projects for comprehensive shelterbelt systems. International cooperation and academic exchanges and research should be encouraged, with the introduction of advanced management expertise. On funding support, there should be efforts to increase gradually the direct input from governments at various levels into the development of the ecological forestry programmes. A compensation mechanism should be set up to pay off the ecological benefits according to which those who receive benefits shall pay for them. Financial assistance from enterprises, public institutions, individuals, foreign governments, international organizations and private donors should be sought. In addition, strict enforcement of the forest laws, forest policy and institutional reforms, and adoption of specific regulations and rules to protect and manage shelterbelt systems and prevent illegal destruction should be implemented.

Shelterbelt management should not only pay attention to long-term ecological and social benefits, but must also consider the immediate economic benefits, and timber, commercial and fuelwood plantations should be important components of a protection forest project. With regard to production structure, diversified economy and integrated development should be encouraged. Projects with immediate benefit should be promoted so as to compensate for those with long-term benefits. It is crucial to improve on a large scale the existing networks of shelterbelts, to introduce tree species with greater stability, to increase economic and landscape trees and to find more uses, and to build a multi-functional integrated forestry, agricultural and ecological system so as to guide farmland ecosystems, agriculture and animal husbandry onto a path of sustainable development.

At present, the establishment of China's shelterbelts is developing into a comprehensive system of ecological types. The research work has developed from qualitative description to quantitative analysis, and from single item to a comprehensive project, integrating vegetation (trees and crops), atmosphere and soils into a complete system. New techniques of remote sensing, micro-meteorology, and simulated ecological experiment are being used for in-depth research to reveal the proper structure, functions and mechanism of agricultural benefits from the shelterbelt systems. All these efforts are aimed at developing shelterbelt systems in China.

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19

Agricultural Biotechnology in Southern Africa: A Regional Synthesis

Doreen Mnyulwa and Julius Mugwagwa

The Convention on Biological Diversity (CBD) defines biotechnology as 'any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use'. Defined this way, it clearly emerges that biotechnology is an old science, with many established uses in areas such as agriculture, medicine, forestry, mining, industry and environmental management. The old applications are generally referred to as traditional biotechnology, and in agriculture these have been in use since the advent of the first agricultural practices for improvement of plants, animals and microorganisms (Persley and Siedow, 1999).

The application of biotechnology to agriculturally important crop species, for example, has traditionally involved the use of selective breeding to bring about an exchange of genetic material between two parent plants to produce offspring with desired traits such as increased yields, disease resistance, and enhanced product quality. The exchange of genetic material through conventional breeding requires that the two plants being crossed be of the same or closely related species.

The generations of biotechnology

The progress and development of biotechnology is generally divided into three broad categories, also referred to as generations of biotechnology. This acknowledges that biotechnology is not a new technology, but rather is a continuum of techniques and approaches that have evolved over time.

The first generation. This refers to the phase of biotechnology that was based on empirical practice, with minimum scientific or technological inputs. This phase stretched all the way from 12,000 BC to the early 1900s.

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The second generation. Developments in fermentation technology, especially during the period between the two world wars, constitute what is generally referred to as the second generation or phase of biotechnology. Major products from this generation were antibiotics such as penicillin and other products such as vitamins and enzymes. Another critical event of this generation, beginning in the 1930s, was the development and use of hybrid crop varieties in the US Corn Belt, which resulted in dramatic yield increases.

The third generation (new biotechnology). The third generation or phase of biotechnology, also referred to as the new or modern biotechnology, is the present one. A turning point occurred in 1953 with the discovery at Cambridge University (UK) of the structure of deoxyribonucleic acid (DNA), which is the molecular carrier of stored information. DNA is a long and winding molecule that is made up of a combination of several chemicals. Four related chemicals in DNA, called 'bases', are lined up in specific sequences, and these specific sequences represent the information that determines the traits, features, characteristics, abilities and functioning of cells within an organism.

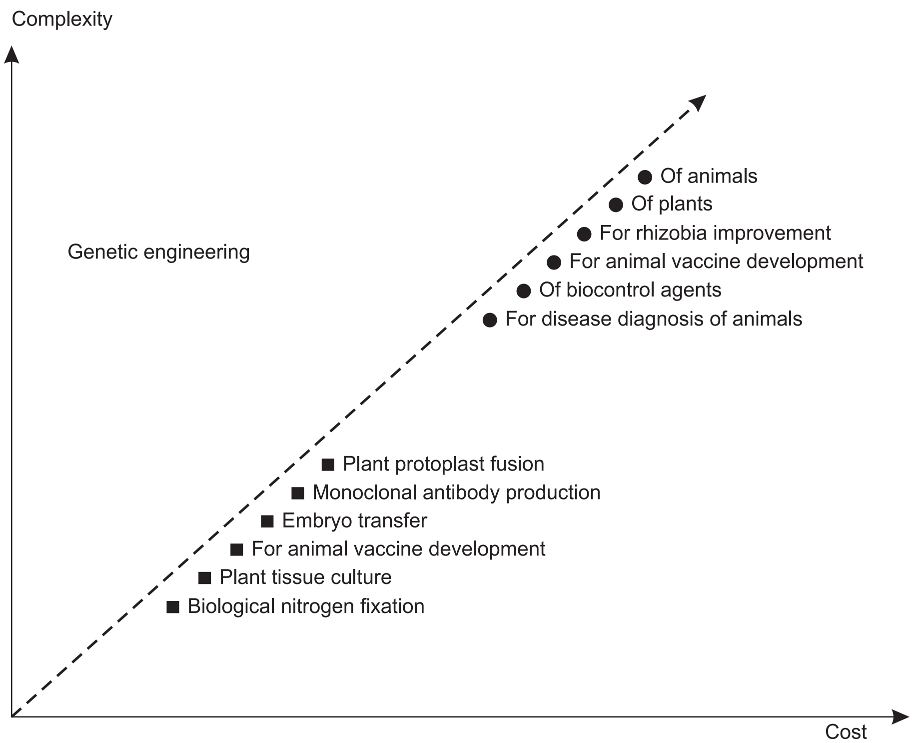
The particular segment of DNA that contains information for a particular characteristic or trait is called a gene. In other words, the genes represent information that is passed on from one generation to the next. It is also important to point out that not all segments of DNA represent information that can be or is passed on from one generation to the next. Because DNA is made up of chemicals that are present in cells where many life-maintaining processes are occurring, the DNA needs to 'protect' itself, and hence some segments of the DNA serve the purpose of ensuring that the DNA remains intact.

The current status of biotechnology research and use in the SADC region

Countries in the Southern African Development Community (SADC) region are employing various forms of biotechnological techniques in their agricultural, environmental management, forestry, medicine and industry efforts, and have been since time immemorial. However, without doubt Africa is the region where biotechnologies are the least developed. There are many different explanations for this situation, but several schools of thought associate it with the perennial economic problems affecting the continent (Sasson, 1993).

Figure 19.1 shows the gradient of biotechnologies in terms of complexity and costs. An analysis of the status of biotechnology in the different SADC countries will be presented and discussed based on this gradient.

From studies conducted by the Biotechnology Trust of Zimbabwe (BTZ) in 2001 and 2002, and studies by other organizations such as the Rockefeller Foundation and International Service for National Agricultural Research, it can be seen that the main area in which biotechnology techniques are being applied in southern African countries is agriculture, with the major thrust being crop improvement. Techniques such as tissue culture are being applied in almost all the countries,



Source: Sasson, 1993

Figure 19.1 *Gradient of biotechnologies in Southern African Development Community countries in terms of complexity and costs, 1993*

mainly because of the less intensive nature of this technique in terms of human and infrastructural resources.

Modern biotechnological techniques, which include genetic engineering, are being employed in a few of the countries, namely Malawi, South Africa and Zimbabwe, and to a small extent in Mauritius and Zambia. Of all these countries, only South Africa has reached the commercialization stage insofar as products of genetic engineering are concerned. The rest are still at the laboratory research stage.

Tied closely to the issue of research is the development and implementation of regulations to monitor the research and products thereof. Only three countries in the region, namely Malawi, South Africa and Zimbabwe, have legal mechanisms for biosafety, that is, the safe development and application of biotechnology. The rest are still at varying stages in the development of their biosafety systems. All countries of the SADC region are signatories to the Cartagena Biosafety Protocol, an addendum to the CBD, which governs safe trans-boundary movement of living modified organisms, among other provisions for ensuring safety in biotechnology.

Table 19.1 gives details on the status of development and use of various biotechnological techniques in the southern African countries.

Table 19.1 *Status of development and use of biotechnology techniques in Southern African Development Community countries, 2002*

Techniques/category	*Areas of application*			
	Angola	*Botswana*	*Democratic Republic of Congo*	*Lesotho*
Tissue culture (TC)	Little is known	Used on a limited basis for root and tuber crops	Little is known	Used in Irish potato production and micropropagation
Genetic modification (GM)	Little is known	Limited research is being done at the University of Botswana. No field trials have been approved	Little is known	None
Fermentation technology	Little is known	Used in the brewing industry	Little is known	None
Marker-assisted selection	Little is known	None	Little is known	None
Artificial Insemination and embryo transfer	Little is known	Used in livestock breeding	Little is known	None
Molecular diagnostics and molecular markers	Little is known	Used on a limited basis in plant and animal disease diagnosis	Little is known	None; serological techniques are still being used
Biological nitrogen fixation	Little is known	Used mainly through integration of legumes in cropping systems	Little is known	Used for legumes only
Manpower training	Little is known	Training is offered in other natural science modules at the University of Botswana	Little is known	Undergraduate and graduate training is done in natural and agricultural science (National University of Lesotho)

Table 19.1 *(continued)*

	Areas of application		
Techniques/category	*Malawi*	*Mauritius*	*Mozambique*
Tissue culture (TC)	Used in disease elimination and micropropagation for cassava, sweet potatoes, Irish potatoes and horticultural crops	Used on a limited basis in sugar cane research	Used in cassava and Irish potato production, micro-propagation and disease elimination
Genetic modification (GM)	At the research level for cassava improvement (virus resistance). *Bt* cotton trials have been conducted.	GM sugar cane is nearing field trials. Awaiting adoption of a biosafety framework	None
Fermentation technology	Used for food and feed production	Widely used in the brewing industry	None
Marker-assisted selection	None	None	None
Artificial Insemination and embryo transfer	Used for cattle breeding	Used on a limited basis	None
Molecular diagnostics and molecular markers	At the research level for use in animal disease diagnosis and diversity studies	Serological techniques are still used for diagnosis	Serological techniques are still being used
Biological nitrogen fixation	Used for legumes only	Used for legumes	Used on a limited basis, for legumes
Manpower training	Training is done in the natural and agricultural sciences (Bunda College of Agriculture). Most of the training is theoretical. No explicit biotech courses are offered	No explicit biotechnology training is offered	Limited training is done in the natural sciences and agriculture (Eduardo Mondlane University)

Table 19.1 *(continued)*

	Areas of application		
Techniques/category	*Namibia*	*Seychelles*	*South Africa*
Tissue culture (TC)	Used in cassava and Irish potato production, micropropagation and disease elimination	Little is known	Active programmes have been developed employing TC techniques for root and tuber crops, ornamental and horticultural crops, and animal vaccine production
Genetic modification (GM)	None	Little is known	Most major universities and research institutions (both government and private) have major projects employing GM techniques. Both crops and animals are covered in the research activities. Insect-resistant cotton and maize and herbicide-tolerant cotton and soybeans are already being grown commercially
Fermentation technology	Used in food processing (small-grain crops)	Little is known	Used widely in food and beverages as well as in pharmaceutical industries
Marker-assisted selection	None	Little is known	Used in maize and small-grains breeding as well as livestock research and development
Artificial insemination and embryo transfer	Used in cattle breeding	Little is known	Used in livestock research, breeding, and conservation
Molecular diagnostics and molecular markers	Serological techniques are still being used	Little is known	Used for plant and animal disease diagnosis
Biological nitrogen fixation	Used for legumes only	Little is known	Used for soil fertility improvement through legumes and inoculants
Manpower training	Limited training is done, but University of Namibia is currently pursuing setting up an MSc programme in biotechnology	Little is known	Specific degree-level training programmes are available at most major universities, with access to state-of-the art resources

Table 19.1 *(continued)*

	Areas of application		
Techniques/category	*Swaziland*	*Tanzania*	*Zambia*
Tissue culture (TC)	Used in Irish potato production and micropropagation	Techniques are employed relatively extensively for root and tuber as well as horticultural crops	Used in micropropagation and disease elimination for cassava, sweet potatoes, Irish potatoes, mushrooms and planting materials
Genetic modification (GM)	None	Limited research is being done, e.g. on virus resistance in bananas. There have been no commercial releases, but trials on GM tobacco were conducted in 2002	Use limited; still at the research level for cassava improvement (virus resistance). Confined trials of *Bt* cotton were conducted in 1999/2000
Fermentation technology	None	Used in the brewing industry and vaccine production	Used for food and feed production
Marker-assisted selection	None	Used in genetic characterization of coconuts, cashews, sweet potatoes, cassava and coffee	None
Artificial insemination and embryo transfer	Used in cattle breeding	Used in livestock breeding and conservation	Used for cattle breeding
Molecular diagnostics and molecular markers	Serological techniques are still being used	Used in plant and animal disease diagnosis	Used for plant and animal disease diagnosis and diversity studies
Biological nitrogen fixation	Used for legumes only	Used mainly for legumes; used on a limited basis for inoculants	Used for both legumes and inoculants
Manpower training	Training is done at the undergraduate level in natural sciences (University of Swaziland)	Training is done in agricultural and other life science courses. A BSc degree in biotech was recently introduced at Sokoine University. The country is also benefiting from the BIO-EARN (East African Regional Network on Biotechnology and Biosafety) programme	Training is done in the natural, veterinary and agricultural sciences (University of Zambia). No explicit courses are offered in biotech

Table 19.1 *(continued)*

	Areas of application
Techniques/category	*Zimbabwe*
Tissue culture (TC)	Used in micropropagation and disease elimination for sweet potatoes, mushrooms, Irish potatoes and horticultural crops
Genetic modification (GM)	Still at the research level, mainly for use in crop improvement for cowpeas, tobacco, maize and sorghum. Confined trials of *Bt* maize and cotton have been conducted
Fermentation technology	Used in food processing, feed and vaccine production
Marker-assisted selection	At the research level for improvement of maize for drought resistance and for small-stock improvement
Artificial insemination and embryo transfer	Used for cattle and small-stock breeding
Molecular diagnostics and molecular markers	Used for plant and animal disease diagnosis and diversity studies
Biological nitrogen fixation	Used for soil fertility improvement for both legumes and inoculants
Manpower training	Specific biotech training programmes have been developed at both undergraduate and graduate levels (University of Zimbabwe, National University of Science and Technology, Africa University)

Source: Mnyulwa and Mugwagwa, 2002

Biosafety Systems

An analysis of the SADC countries looking at the status of their development and use of policy systems to ensure the safe development and application of modern biotechnology shows that the countries are at different levels. They can be placed into three broad categories: those that have regulations, those that have draft regulations and those that have yet to initiate or are still in the very initial stages of development of such regulations. Table 19.2 summarizes the countries' status.

Global and regional trends in the production of GMOs

Worldwide it is estimated that more than 3 billion people have been consuming GM foods since their commercialization in 1996. The use of GM plant varieties represents the fastest adoption of a new technology according to reports of the International Service for the Acquisition of Agri-Biotech. The total land area devoted to cultivation of GM crops increased from 1.7 million hectares in 1996 to 52.5 million hectares in 2001 (James, 2001). By 1998 some 40 new GM varieties were being cultivated worldwide, mainly in Argentina, Australia, Canada, China, France, Mexico, South Africa, Spain and the US.

The area of GM crops in the developing countries has increased over the years from 15 per cent in 1998 to 25 per cent in 2001, of which 22 per cent was planted in Argentina and 3 per cent in China. China is the only country where public researchers funded by the government produced and commercialized GMOs.

Trends in Southern Africa

Currently it is only South Africa that has commercialized GM crops. Both the commercial and small-scale farmers are cultivating these. Table 19.3 shows figures on the trends of adoption of GM crops in the Makhathini Flats (Kwazulu-Natal Province), the first smallholder farming area to adopt the GM varieties of cotton. GM white maize has been commercialized (2002/2003 season) in South Africa, and this will cause a number of smallholder farmers to adopt the cultivation of GM crops.

Overview of GM use in the SADC region

The use of biotechnology in the medical sciences is generally well accepted. Its use in agriculture is mixed; for example, South Africa is well into the use of GM crops, while the rest of the SADC nations are still behind. Importation policies are not clear, especially because producers from countries like the US do not label GMO products.

Table 19.2 *Status of development and use of biosafety systems in Southern African Development Community countries, April 2003*

Biosafety issue	*Angola*	*Botswana*	*Lesotho*	*Malawi*
Status of development and implementation	There is no biosafety legislation at the moment. The Ministry of Agriculture has initiated discussions on biotechnology and biosafety issues.	There is no biosafety legislation in this country. A process to develop a national biosafety framework was initiated in 2002 with funding from the United Nations Environment Programme (UNEP) and the Global Environment Facility (GEF). The National Coordinating Strategy Agency is the national focal point for biosafety.	A biosafety committee was set up in 2001 within the Environmental Protection Unit to initiate drafting of legislation. Very limited capacity for risk assessment	Has legally binding legislation on biosafety. A national biosafety committee was appointed, though the country has limited capacity for risk assessment.
Use of biosafety system in regulation of work on or use of genetic engineering (GE)	It has been reported that GE grain imported by Namibia in 2001 was milled in Angola. Namibia's draft legislation guarded against contamination of the environment. Angola had and still has no regulations	As indicated, there are no mechanisms in place to regulate GE and its products. The dependence of the country on agricultural produce from South Africa is a cause for concern.	There have not been any official reports of requests to conduct trials or import GM products. Absence of a biosafety system complicates the situation. However, some food products, especially from South Africa, are suspected to be GM.	An interim committee was consulted in the debate on whether Malawi should import GM food aid or not. Malawi accepted GM maize, with no conditions set.
Urgent requirements	Regulations, capacity building, public awareness	Development of a legal framework, capacity building, public awareness and participation	Garnering support from policy makers, development of regulatory framework, capacity building, public awareness	Raising awareness of new legislation among stakeholders, capacity building

Table 19.2 *(continued)*

Biosafety issue	*Mauritius*	*Mozambique*	*Namibia*	*Seychelles*
Status of development and implementation	Has a GMO bill that requires setting up a national biosafety committee (NBC)	Set up a committee within the Ministry of Environment to come up with interim legislation on biosafety. Legislation still being developed.	Has a national biosafety committee (the Namibian Biotechnology Alliance) and draft legislation. Also has very limited capacity for risk assessment.	Discussion of biotechnology and biosafety issues has only just started in this country to whose economy agriculture contributes only marginally. The main worry is that the country is a net food importer.
Use of biosafety system in regulation of work on or use of genetic engineering (GE)	Officially, no GE products have entered the country. The NBC is tasked with monitoring the registration and movement of GE products in the country. A locally developed GM sugar cane variety is awaiting release.	Has already officially received GM maize under the condition that it has to be milled before distribution to consumers. A framework is still needed to ensure effective monitoring of GM products.	Accepted milled GM maize in 2000. Rejected GM maize in 2002, and instead received food aid in the form of wheat, as per a recommendation by the national biosafety committee.	Importations of foodstuffs have been handled under the existing food and food standards regulations
Urgent requirements	Regulations, capacity building, public awareness	Development of regulatory framework, capacity building, public awareness	Finalizing processes for regulation development, capacity building and public awareness	Awareness raising, regulations, capacity building

Table 19.2 *(continued)*

Biosafety issue	*South Africa*	*Swaziland*	*Tanzania*
Status of development and implementation	Has had a legally binding GMO Act since 1997; also has the institutional framework to administer the act. The country has a number of both public and private laboratories adequately equipped to do GE work. Has more than 110 plant biotech groups, more than 160 plant biotech projects, and more than 150 trials.	Set up a committee within the Environmental Protection Agency to come up with interim legislation on biosafety. Legislation still being developed.	A national biosafety coordinating committee was set up under the government's Division of the Environment in November 2002. This activity is taking place under the UNEP-GEF project.
Use of a biosafety system in the regulation of work on or use of GE	Already has a number of GE research work projects and products on the ground, including commercial cultivation of GM horticultural crops, cotton and maize by smallholder farmers	Has already officially received GM maize under the condition that it has to be milled before distribution to consumers. *Bt* cotton and maize are currently being grown by farmers in parts of South Africa bordering Swaziland, and thus there is fear for possible contamination.	Tanzania has been a port of entry for GM maize provided as food aid to some countries in the region. Consignments were handled under the existing phytosanitary regulations.
Urgent requirements	Review of legislation, public awareness and participation	Obtaining stakeholder support, especially from policy makers, as well as regulation development	Regulations, resource mobilization, public awareness

Table 19.2 *(continued)*

Biosafety issue	*Zambia*	*Zimbabwe*
Status of development and implementation	Has draft legislation and a national biosafety committee. Limited capacity for risk assessment. Currently in the process of coming up with a national biotechnology strategy.	Has a legally binding biosafety system, which includes a biosafety board and its secretariat, as well as biosafety regulations and guidelines. Has some laboratories, which have the capacity to detect genetically modified organisms (GMOs).
Use of a biosafety system in the regulation of work on or use of GE	An interim committee recommended rejection of GM food aid (July 2002). A case of unapproved trial of GM maize was reported in 1999 (personal communication with Monsanto, 2001).	Two field trials were approved in 2001, for *Bt* cotton and *Bt* maize. No commercialization has been approved as yet. Assessed applications for importation of GM maize; importation granted with conditions.
Urgent requirements	Enactment of legislation, capacity building, public awareness	Review of current legislation, capacity building, public participation in decision making processes

Source: Based on Mnyulwa and Mungwagwa, 2002, but updated through continuous interaction with partners

Table 19.3

Season	*Percentage of farmers cultivating* Bacillus thuringiensis (Bt) *cotton*
1998/1999	18
1999/2000	60
2000/2001	71

Public Dialogue, Public Awareness and Policy Responses

Background

Proponents of GM technologies cite several potential benefits that can accrue to society. These benefits include enhanced taste and quality of foods; nutritional enhancement of foods for chronically malnourished populations; reduced maturation times for crops, leading to labour savings; and enhanced tolerance of biotic and abiotic stresses for crops, leading to reduced dependence on herbicides and pesticides. But these perceived benefits are not uncontroversial.

As a result of the intense debate and controversy surrounding the development and use of GMOs it is important for countries to engage in wide stakeholder dialogues in order to ensure that people are equipped to make informed choices. The public ought to participate even in the development of frameworks for regulation of GM research and development work. The main reasons for public awareness of and participation in the development of national biosafety frameworks (NBFs) are to promote participatory decision making and involve all sectors of the society, to bridge the differences between various parts of society concerning the safe use of living modified organisms (LMOs), to ensure the use of an inclusive process involving all stakeholders, to share a common vision and purpose, to promote improved decision making based on information, and to promote transparency in the decision making process. It is important to note that the development of NBFs goes beyond the creation of a document. It inevitably encompasses wider issues about the role of biotechnology and requires ongoing participation in biosafety processes after regulations have been developed. The process itself calls for commitment and the creation of an appropriate environment to access participatory mechanisms, capacity building, information dissemination and strategies for involvement of all stakeholders.

Participation in biosafety is prescribed in Article 23 of the Cartagena Protocol on Biosafety (United Nations Environment Programme, 2002):

> Public awareness and participation:
> 1) Parties to the protocol shall:
>   a) Promote and facilitate public awareness, education and participation concerning the safe transfer, handling and use of living modified organisms in relation

to the conservation and sustainable use of biological diversity, taking also into account risks to human health. In so doing Parties shall cooperate, as appropriate, with other states and international bodies;

b) Endeavour to ensure that public awareness and education encompass access to information on living modified organisms identified in accordance with this Protocol that may be imported.

The Parties shall, in accordance with their respective laws and regulations, consult the public in the decision making process regarding the living modified organisms and shall make the results of such decisions available to the public, while respecting the confidential information in accordance with article 21.

Participation is crucial in the analysis of the issues, in decision making and strategic planning, in implementation, and in monitoring and evaluation. Stakeholders can be defined as people from government agencies and the private sector, groups or individuals whose lives and interests could be directly or indirectly affected, and bodies, groups or individuals with particular knowledge that could be called upon.

Public awareness was defined by the participants of a UNEP workshop on risk assessment and risk management held in Namibia in 2002 as a process of providing universal access to information (providing balanced information in terms of pros and cons), enlightening the public, and thereby providing for informed participation. *Public participation* was defined as involving stakeholders (at all levels of society) in decision making processes (giving everyone a chance to express their views) and taking their suggestions into consideration in making a decision. Public awareness and participation are needed for:

1 consensus building on issues that affect people directly or indirectly;
2 ensuring implementation of the decision;
3 building transparency and accountability;
4 facilitating informed participation;
5 achieving a better position from which to take action;
6 facilitating inclusiveness;
7 providing balanced information in terms of pros and cons;
8 harmonizing institutions that provide awareness activities;
9 removing bias;
10 building a sense of ownership and collective responsibility;
11 building stakeholder confidence;
12 bridging the knowledge gap;
13 ensuring sustainability;
14 minimizing conflicts;
15 creating a platform for action; and
16 attracting attention and interest.

Status of public awareness in the SADC region

Different countries in the SADC region have sought to promote and facilitate public awareness and participation in the design and implementation of their NBFs. Different tools and approaches have been suggested by various efforts (see United Nations Environment Programme, 2003a). Participants at a UNEP-GEF Namibia workshop on risk assessment, risk management, public awareness and public participation for sub-Saharan Africa held in Namibia in 2002 proposed an action plan for enhancing public awareness and participation in the southern African region (see United Nations Environment Programme, 2003a).

It is the responsibility of each party to determine the combination of the proposed tools suitable for their specific situation. In most countries in the region the lack of biosafety frameworks is partially attributed to these countries' lack of awareness at various levels of the importance of both the technology and the need for biosafety policy. Table 19.4 summarizes the levels of biotechnology awareness in the SADC countries, including the awareness-raising tools and approaches being employed in the different countries.

The challenges of public participation

The public awareness levels shown in Table 19.4, together with the efforts to arrive at such levels, are confounded by many factors, some of which are discussed in this section.

Commercial confidentiality. One of the major challenges of public participation is defining the limits of confidentiality for the provision of information to the public. A statute on access to information might be needed, or the responsibility for deciding what represents confidential information might be given to the national governments in consultation with the companies concerned.

The costs of various levels of participation. These costs need to be planned for and addressed during the planning period. They have to be dealt with in the context of the limited human, infrastructural and financial resources of most of the countries.

The diversity of the various developing countries' farming systems and other cultural and social factors. This diversity makes it difficult to come up with a common framework for the involvement of stakeholders in the decision making processes.

High science. How does one simplify highly scientific information to facilitate and increase the comprehension of the concepts by the general public, the majority of whom are illiterate? Challenges exist regarding how to effectively communicate science to a public of such a dynamic background as obtains in most of the developing SADC countries, where stakeholders have different priorities to address and

Table 19.4 *Levels of biotechnology awareness and public awareness strategies in Southern African Development Community countries, March 2003*

Country	*Levels of biotech awareness*	*Strategies used for information dissemination and awareness raising*
Angola	Low (assumption)	Little is known about strategies
Botswana	Low overall	Uncoordinated and sporadic activities, mainly announced through newspaper articles and led by scientists and to some extent the consumer movement
Democratic Republic of Congo	Low (assumption)	Little is known about strategies
Lesotho	Low overall	A few sporadic activities, mainly driven by scientists
Malawi	Average among scientists, low among other stakeholders	Discussions in the form of workshops and meetings, mainly coordinated by Bunda College and the National Biosafety Committee. Other tools are mainly sporadic debates and responses via the local press.
Mauritius	Low overall	A few, largely sporadic, activities coordinated by the National Biosafety Committee
Mozambique	Low, even among scientists	Still largely uncoordinated and reactive efforts for coordination through the Africa-Bio and Southern African Regional Biosafety programmes
Namibia	Average to low	Some activities coordinated by the National Biotechnology Alliance, the farmers union, and the consumer movement
Seychelles	Low (assumption)	Little is known about strategies
South Africa	Average among the affluent groups but low among smallholder farmers and general consumers	Formal media and informal channels (including websites, leaflets and public debates) sponsored by a number of non-governmental organizations and companies such as Africa-Bio, Biowatch, SAFeAGE (South African Freeze Alliance on Genetic Engineering), A-Harvest, and Monsanto. Notices of application for trials or release of genetic engineering (GE) products are published in the government gazette to solicit public comments.
Swaziland	Low overall	A few sporadic activities, mainly driven by scientists
Tanzania	Average to low	A few activities, some coordinated by the National Biosafety Committee, some by scientists, and some by the Commission for Science and Technology

Table 19.4 *(continued)*

Country	*Levels of biotech awareness*	*Strategies used for information dissemination and awareness raising*
Zambia	Average to low among scientists, low among the rest	A few, largely uncoordinated and irregular, activities such as debates and discussions organized by the National Biosafety Committee, the National Farmers Union and the consumer movement
Zimbabwe	Average among the scientists, low among stakeholders	Advertisements in the government gazette soliciting public comments. A number of organizations engage in information dissemination (e.g. the Biotechnology Trust of Zimbabwe, the Biotech Association of Zimbabwe, the Consumer Council, the Pelum Association, COMMUTECH (the Community Technology Development Trust), the Intermediate Technology Development Group, and the biosafety board, among others. The main channels used include workshops, seminars, debates, information brochures, radio and television discussions, etc.

Source: Based on Mnyulwa and Mugwagwa, 2002, but updated through continuous interaction with partners

have to deal with a language barrier (explaining science in local languages is impossible in most cases). It is noted that dialogue requires honesty, openness, transparency and inclusiveness, along with mutual respect and an absence of mistrust. The starting point for dialogue should be the premise that the public has valid views that need to be voiced and understood, taking into account room for variance. Public participation has to be based on access to information, and it is necessary for national governments to facilitate the packaging of information in a way that meets the stakeholders' needs.

External influences. Many such influences affect decisions taken by developing countries on the commercial use, risk assessment, and risk management issues related to LMOs. Trade in GM crops and products will be subjected to the international agreements signed by the member states. The majority of the developing countries, SADC countries included, are parties to the World Trade Organization (WTO), and thus the protocol is supposed to allow free and equitable trade. Yet the following issues need to be taken into account:

- GMOs require special clearance mechanisms to allow developing countries to make a choice – to accept or reject GMO goods and not be bound by the WTO provisions alone.

- An exporting country is not liable for damage and environmental pollution due to GMOs.

National laws are needed on labelling both the grain and seed and any blended products. Experience so far has shown that the use of GMOs in developing countries is dictated by trading partners such as the European Union.

The murky interface (food aid, politics, science, and regulations). A number of public concerns resulting from the use of modern biotechnology relate to their impact on trade, the environment and health. Says David Dickson of SciDev.Net: ‘On closer inspection, the decision by Zimbabwe and Zambia begins to lose some of its apparent naivety. The real fear officials of these countries are said to have explained to the officers of the World Food Program, is not the health danger that these foods are said to cause. Rather it is that if GM maize seed is planted rather than eaten, there could be “contamination” of local varieties, and this will mean that the agricultural produce of these two countries, including beef fed on the crops, could no longer meet the “GM free” criteria demanded by European Markets’ (www.scidev.net/archives/editorial/comment28.html). A study by Environment and Development Activities in Zimbabwe after the 1991/1992 drought revealed that about 20 per cent of the smallholder farmers from some selected districts of Zimbabwe had retained the yellow maize grain provided as drought relief to use as seed. So the danger that GM maize grain will find its way into the seed system is real.

Most of the developing countries’ positions are compromised by those of their trade partners, whether Europe or America. The conflicting positions of the two major trading partners of most southern African countries has greatly influenced the current positions adopted by the various nations.

The US, one of the major suppliers of food relief, has been commercially growing GM crops for the past 5 or 10 years, and they do not segregate or label these products. The political dimension of the debate over southern African hunger and GM maize is that the US appears to be using the current famine as a cover to promote acceptance of a technology ‘enthusiastically embraced by its own corporations, while remaining widely distrusted in Africa’ (Dickson, 2002). The US has shown frustration with African critics of its food offer, and has also shown reluctance to provide funds for processing the maize, conditions that have further fuelled the political dimension. A statement in early 2002 by one US official that ‘beggars cannot be choosers’ has further haunted the humanitarian effort.

The absence of regulations for monitoring the movement of GM material in most of the affected countries is another problem. Personal communications with some authorities in Zambia have shown that although the trade, food safety and environmental dimensions have been mentioned, one salient but important dimension has not: that of regulations. The affected parties have feared that lack of a legal framework would frustrate any efforts to ensure monitored and controlled movement of the GM maize once it was released to the population. The situation in Zimbabwe has been different because regulations were in place already, and

Malawi (then) was at an advanced stage in the development of its regulatory framework; hence it has been possible for decisions to accept the GM maize to be made.

The situation that has been faced in southern Africa points to the reality that countries have to accept regarding the impact of modern science on society – that it involves a complex of scientific, economic and political factors that cannot easily be reduced to any single dimension (Dickson, 2002).

The Public Awareness Effort in Southern Africa – A SWOT Analysis

Below is a strengths, weaknesses, opportunities and threats (SWOT) analysis (Table 19.5) of the public biotechnology awareness effort in southern African countries. This analysis is adapted from results of the UNEP-GEF workshop held in Windhoek, Namibia, in November 2002.

Recommendations

Mindful of the situation prevailing in the SADC region with respect to biotechnology, and cognizant of the role that the technology can play in agriculture and food security issues, we recommend that the following needs be addressed.

Development of the capacity to make decisions

One critical issue that emerged from the 2002 debate on food security vis-à-vis the use of GM maize as a food aid was that the majority of countries in the SADC region lacked the regulatory and scientific structures necessary to take decisive steps. During the BTZ's regional consultation on the status of development of biosafety systems in eastern and southern African countries, it emerged as a major sticking point that most countries did not prioritize development of regulatory structures for biosafety, mainly because of the low level of biotechnology research and development activities in their countries. If the lessons drawn from the 2002 GM food aid debate are anything to go by, countries in the region are best advised to put regulatory and scientific monitoring mechanisms in place, because the GM products in the region are not the products of research efforts in the region, but rather are products introduced from elsewhere. The scenario is the same as that for products of most other technologies, but the need for regulations remains critical. The GM debate underlined the fact that in a globalized economy the development of regulations is a necessity, not a luxury.

The development of scientific and infrastructural capacity is not an overnight activity. Given the varying levels of capacity and resource endowment in the countries

Table 19.5 *Strengths, weaknesses, opportunities and threats analysis of public awareness and public participation in southern Africa, November 2002*

Strengths	High literacy level
	Political will (many countries in the region have signed the Biosafety Protocol)
	Common official language, facilitating information dissemination
	Existing administrative structures
	Information-sharing structures
	Existing human resources (biotech specialists, etc.)
	Relevant legislation and policies
Weaknesses	Limited programmes on and capacity for modern biotechnology
	Lack of policies on biotechnology and biosafety
	Ignorance of biotechnology, which impedes the dissemination of information
	Lack of sustainable funding
	Science illiteracy
Opportunities	Existing public awareness and participation programmes that can be used to disseminate information, e.g. HIV/AIDS awareness programmes
	Decentralized system of governance
	Availability of UNEP-GEF funding
	Existing subregional programmes (SADC)
	Innovative financial instruments that could be used to generate additional funds for programmes in the form of taxes, levies and other fees
Threats	Lack of networking among scientists and with other political and civic leaders
	Lack of communication between scientists and other interest groups such as sociologists, politicians and civil society

Source: United Nations Environment Programme, 2003b

of the region, mechanisms for collaboration and the development of synergistic relationships need to be put in place for countries to be able to pool their resources. Through the SADC and regional as well as national governmental and non-governmental organizations with activities in the areas of agriculture, the environment, and biotechnology and biosafety, activities can be implemented for the development and strengthening of national and regional capacities that will enable informed decision making on GM products. Arrangements for the transfer of technology and expertise should also be entered into with institutions within the region and beyond that can provide such expertise. Individual countries and the region should place an emphasis on developing their own capacity to do the work so they can become self-sufficient in the long run.

The SADC countries should also be cognizant that genetic engineering is building on the achievements of other accepted and established techniques such as tissue culture, molecular biology, fermentation technology and so on. Countries need to develop a capacity for these techniques, not necessarily to use them as a foundation for genetic engineering, but to exploit them and assess whether some of the agricultural production constraints can be solved using such technologies. Examples abound from Colombia, India, Kenya and Zimbabwe, where tissue culture programmes have been successfully implemented to provide sufficient quantities of high-health status planting materials for crops such as bananas, yams, cassava and sweet potatoes.

Identification of regional needs and priorities

For the region and individual countries to realize some of the benefits to be derived from the employment of modern biotechnology techniques, they need not only to develop regulatory and scientific capacity, but also to identify needs and priorities for intervention at national and regional levels. Priorities would include targeting crops or animals for the research efforts, along with traits to be researched (drought tolerance would be an obvious choice) and the human and infrastructural capacity needs of the countries and the region. Genetic engineering technologies invariably need substantial financial investment, and the SADC countries would best be advised to invest in areas in which they have sustainable competitive advantages or in areas that address their priority food security needs.

Creation of an enabling environment for research about or use of biotechnology products

The development and implementation of regulations is one avenue for creating an enabling environment for biotechnology research and development as well as for the use of products of genetic engineering. The SADC countries need to develop appropriate biosafety systems for monitoring and controlling biotechnology activities in them. Given that the region already has three countries with legal biosafety systems, experience-sharing mechanisms can be put in place and employed so countries can learn from each other about the development and use of such systems. Discussion among policy makers needs to be stepped up so as to garner the necessary political will. For example, in Zambia efforts to put policies in place are thwarted not only by lack of funding and scientific expertise, but also by lack of political will. This certainly is the case in most of the countries of the region.

Stakeholders need to develop strategies for ensuring that national governments prioritize policy development and investment in infrastructural and human capacity for biotechnology activities, and at least some measurable capacity for risk assessment and risk management. In a 2001/2002 eastern and southern African study on the status of development and implementation of biosafety systems conducted by the BTZ, one of the major findings to emerge was that the source of information most trusted by the lay public was one to which local researchers would have made a contribution. One way to achieve this end is to raise the general level of discourse about biotechnology issues both in the individual countries and at the regional level. With an increased awareness of the potential dangers and benefits of genetic engineering technology, policy makers will be in a better position to see the need to develop the necessary legislative frameworks. Awareness also needs to be raised in the general population of the SADC region because people have a right to know whether they should consume certain products. In addition, transparency and trust need to be developed among the private sector, local researchers, national governments and all stakeholders in the region with respect to the real hazards or benefits presented by genetic engineering technology.

Harmonization of national and regional policies

One major lesson from the food aid debacle is that the countries of the SADC region need to harmonize their legislation in order to facilitate smooth movement and transit of food materials. This harmonization should encompass issues such as standards, risk assessment and risk management procedures, prior informed consent requirements, information and documentation requirements and other issues. In essence the harmonized policies should facilitate the development of procedures for approval of the use and movement of products in the region.

Conclusion

The SADC countries are at different levels in the development and application of biotechnology as well as systems to govern the use of this technology. This scenario should be exploited to ensure that all countries attain a certain minimum level of technical and regulatory capacity, especially for monitoring the development and use of GM technologies and the products thereof. It is crucial for all the countries in the region to realize that they need each other, especially given the increasingly globalized economy and the fluid nature of national boundaries, as well as the limited capacity to monitor cross-border movement of materials. Adequately equipping the general public, especially farmers, will go a long way toward building self-monitoring and -policing mechanisms that will complement efforts by regulatory authorities to limit the unintended spread of GM products in the environment. An informed society will also influence the national research agenda, thereby ensuring that the constrained research and development resources of countries in the region are used to address priority issues. Little is known about the existing institutional framework within which GMO legislation and regulation are likely to be implemented, especially in rural areas. Several questions therefore remain unanswered. For instance, what roles are played by the national, provincial and local governments in the various countries? What scientific testing infrastructure exists to implement regulations? What are the existing leadership structures, especially in rural areas? To what extent will uninformed smallholders rely on opinions, information and advice from village-level leaders in making their choices? What problems and opportunities will result from using the rural governance already in place as a coordinating mechanism for spreading information? What is the degree of transparency and accountability in implementing agencies?

Appendix: Tools for Participation, Consultation, Information and Education

The following tools have been adapted from United Nations Environment Programme (2003b) and from the author's workshop notes.

Tools for participation and consultation

There are a number of strategies or approaches that can be used to engender public participation in discussion on biotechnology issues. Some of these are as follows.

Enabling legal frameworks. Laws on public participation or on rights to information facilitate meaningful public involvement in biosafety decision making.

Routine opportunities for public comment. In many countries, applications for regulatory approval are published in a register with opportunities for public comment as a matter of routine. Although this methodology is commonly used in developed countries (for instance, in Canada, the Netherlands and the UK), it may be especially useful in developing countries, where there are usually limited resources to facilitate participation.

Multilevel consultations. In some countries, public consultations on different aspects of the biosafety framework have taken place at the national level. For example, consultations were held in Zimbabwe to decide whether to accept GM food aid and, once the decision was made to accept it, how to handle the products.

Independent public inquiries. Independent bodies can be designed to facilitate assessment of the risks and benefits of a technology considering broad public interests. These bodies, if well constituted, can target the particular needs of indigenous groups.

Independent advisory committees. The authority and credibility of such bodies depend heavily on their independence of the government and the way they are constituted, that is, the extent to which they include the views of non-scientists and represent a broad spectrum of stakeholders. These are the tools used by most of the SADC countries, such as Malawi, South Africa and Zimbabwe. In some cases these are complemented by advertisements in either the government gazettes or the local press soliciting comments from the public.

Ongoing oversight and evaluation. Stakeholder bodies, such as the African Biotechnology Stakeholders' Forum, can be set up to review biosafety procedures on an ongoing basis.

A bottom-up participatory process. Participatory processes facilitated by credible and experienced non-governmental organizations can help stakeholders at risk of being left out by the government-led consultation processes. Examples include the Citizens Jury facilitated by the Intermediate Technology Development Group in Brazil, India and Zimbabwe.

These tools can be used in combination to facilitate the all-inclusive participation of stakeholders in the decision making process. The challenges presented earlier in this chapter hinder such effective participation in most developing countries.

Tools for information and education

The identification of information gaps through surveys is a good starting point for any awareness and education initiatives. Information collected through these means would help a country's government in the development of a public information campaign using the following tools.

Informal means of disseminating information. Websites, leaflets, advertisements and telephone helplines can be used to explain biosafety processes and how stakeholders can be involved in information dissemination. These can even be translated into local languages. The BTZ has been using some of these methodologies in disseminating information to the rural poor.

The established media. Newspapers, radio and television provide useful routes for informing the public about biotechnology and biosafety regulations. These can be used to educate or inform the public about GMOs. Advertisements can also be used to get feedback on proposed releases of GM products.

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20

Sustaining Cultivation

M. Bell

'You're missing something.'

Dick Thompson and I were sitting at his kitchen table, a well-thumbed copy of the first draft of this book in a stack between us. Dick noted the flash of alarm that passed across my face.

'I like the book. Don't get me wrong. I like it a lot. But at least when you're talking about me, there's something you're missing.'

'What's – ' I started to ask.

'Get along but don't go along.'

This is a phrase that Dick says he heard one day when cleaning a hog waterer on his farm, when no one else was around.[1] It's long been his motto, and he repeats it at almost every event he speaks at. I had clean forgotten about it, I suppose because I had never really underlined it in my mind. It seemed to me an interesting but quirky turn of phrase.

'Get along but don't go along. It's what your book's about.'

He blazed those clear blue eyes at me. I met them for a moment, and then turned away. Then, suddenly, I got it. Finally. Dick saw his meaning land, and his face spread with a three-hundred-acre grin.

He was right. Get along but don't go along is Dick's way of saying, in just six words, something that has taken me nearer to a hundred thousand to say. The phrase neatly captures the tensions between modernism and postmodernism, difference and engagement, stability and change, that the Practical Farmers of Iowa (PFI) farmers seek to resolve. Get along: Here Dick means both getting along with others and getting along in the world. He means to emphasize the importance of community and dialogue as well as the importance of achieving one's practical needs, and how these are interconnected.[2] Don't go along: Dick's point here is not that one should never do what others do, nor that one should, solipsistically, disregard what others have to say. Rather, his point is that one shouldn't do it just for the sake of getting along. In the terms I have been using in the book, just going along would lead to monologue and monologic power, to the suppression of difference and

Figure 20.1 *The view from Highway 71, north of Audubon, Iowa. 2001*

of dialogue's creative power. Dick's motto instead stresses the value of retaining and encouraging difference as *part* of getting along, as part of good relations and the achievement of practical outcomes. Falsely treating all our circumstances as the same leads to both alienation and irrelevance. Consensus is not necessary for getting along. Dialogue is, and for dialogue we need to retain a measure of difference if we are to find interest in what others have to say, and thus cultivate new knowledge as we cultivate their interest in and commitment to what we too have to say.

Which is just what PFI tries to cultivate. Their vision of sustainable agriculture is that it brings people together in dialogue – bouncing ideas off one another, testing propositions against the practical needs of growing food and feeding people in ways that protect the environment – keeps communities vital, and yields secure incomes. PFI does not offer its members the seductive comfort of final answers. Silver bullets are bullets just the same, no less hazardous for their gleam. PFI gives its members people to talk to and a means for comparing practical circumstances, ever adapting others' words to their own thoughts and offering their own words back for others to chew over, to reshape in light of their experiences, and to give back to others once again. It is not a process of adoption-diffusion. It is a process of *adaption*-diffusion.

The draw of monologue, of adoption-diffusion, of the Big Ag way should not be underestimated, though. Like the farmer at the wheel of a big green machine, monologue can give those who accept it a feeling of great power, even though the tractor is something that the farmer did not make and could not make, but merely switches on. It is a pleasure of power, not of control. That is to say, it is a borrowed power, an identity on loan. Although it is borrowed, in an uncertain world many feel they can hope for little more.

Moreover, most farmers find themselves trying to live on borrowed time with this borrowed power. So many acres, so little time. The speeding of the treadmill associated with the Big Ag way is itself a structure of monologue, encouraging farmers to seek the quick answers, the readily available answers, the silver bullets, even if one has a slightly uneasy feeling about the shooters of those bullets. No one can rely on their own experience for everything. We simply don't have time to reinvent the many wheels of our lives. We all have to rely on what others tell us. It's inescapable, unless your plan is to stay in bed for the rest of your life. But the problem gets worse and worse the faster the treadmill spins. And given the local intensification of this treadmill through the farmer's problem, farmers are increasingly less likely to look to their neighbours for answers, lest either party gain an advantage over the other thereby. Instead they turn to the monologic answers that the treadmill itself provides (only sending it spinning all the faster). The Big Ag phenomenology of doing agriculture thus becomes as well a phenomenology of knowing agriculture, of the cultivation of knowledge, of the cultivation of the ignorable, of the cultivation of the self, in this case a largely monologic self.

Cultivating oneself within the monologue of Big Ag does not ultimately ease the lives of most farmers, despite its lure of easy answers. The bankers of borrowed power and borrowed time occasionally call in the loans – not every year, and not on every farmer. But there are payments to be made here, even if they are not in the currency of money alone. This is a deeply disorienting experience for those who have little connection with other conversations of life and self.

To change metaphors, the structures of agriculture are a tough ride, and a lot of farmers get bucked off. It's a real shock when it happens – what I have called a phenomenological rupture. When you're flying through the air, everything you know and do and are comes suddenly into question. Most farmers hit the dirt in a bit of a daze, get up, dust off and see little else to do but to try to get back on the rampaging horse, if they can manage to get a foot in the dangling stirrup and with a mighty heave swing their way back up onto the saddle. And if they can't …

But while you're flying through the air, if the winds are right, you may hear, at just the right moment, of a safer way to land on the rodeo dirt, and of a whole different way to ride when you dust off and get back up. (Maybe you'll even hear of a different, gentler horse.) Not every farmer does. But when you're flying through the air, you listen to the voices in the crowd like you never have before. This moment of phenomenological rupture can actually be a kind of opportunity. So many of the sustainable farmers we interviewed described their decision to change practices as a sudden event. Given the connections between the structures of doing and the structures of knowing, and given the connections of these to the structures of self, there is so much that has to change that very often it needs to be all changed more or less at once – if it is to be changed at all.

PFI is one of those voices in the crowd, and it is a voice with a distinctive manner of speaking. It is a dialogic voice. It is a voice that tells you that you don't have to go along to get along. It is a voice that the farmers of PFI have come, not to adopt as their own, but to adapt to their own.

Farming isn't easy for the members of PFI either. There is still plenty of bucking with the horses they ride as well. Some PFI members eventually wind up leaving the rodeo of farming too. Despite all the environmental, economic, social and possibly health benefits of what they do, the honest truth is that many of them fail. In fact, several of the PFI farmers that appeared in earlier chapters are no longer farming. Roger. Raelyne. Wendell and Terri. I don't know of a survey comparing the survival rates of sustainable and conventional farms, but my impression is that it's much the same for both, although possibly on average sustainable farms survive somewhat longer. Several PFI members I asked about this agreed. If there is a difference in survival rates, it is not so significant that, without a statistical survey, it jumps out at even those closely familiar with the matter.[3]

Sustainable farmers face several disadvantages in the farming rodeo. To begin with, they often start from a position of financial weakness. As we saw in Bell (2004 Chapter 6), economic factors often act as the phenomenological shock that opens farmers up to the possibility of sustainable farming. Such farmers may find themselves just too banged up financially to regain a secure seat in the saddle, although sustainable practices may enable them to stay 'in' farming a few more years. Also, as sustainable farmers tend to farm fewer acres and buy fewer outside inputs, such as machinery and chemicals, ironically they will be more likely to find themselves beholden to banks and merchants, rather than having the banks and merchants equally beholden to them. Because sustainable farmers spend less and borrow less, the balance of beholden-ness is more often tipped against them, making it more probable that the banks and merchants will call in their accounts.

Another disadvantage sustainable farmers face is with the structure of agricultural subsidies. The average Iowa farmer does quite nicely in this respect, with that annual subsidy cheque of $22,400 per farm between 1999 and 2001.[4] But averages disguise a lot. Some 72 per cent of Iowa's farm subsidies go to just 20 per cent of the farmers.[5] Smaller farmers usually get a much smaller check, and big farmers a bigger one. It might seem obvious that smaller farmers would receive less, but the subsidy system is often defended as the saviour of small farms. Moreover, small farms typically receive lower subsidies per farm acre than big farms, particularly when the small farms produce something other than corn and soybeans, corn and soybeans, and corn and soybeans, the two main subsidized commodities in Iowa. Fewer acres and different products being two of their typical characteristics, sustainable farms tend to lose out substantially on farm subsidies.

Take Jon and Heather, for example, small-scale beef farmers. They have been getting about $6000 in annual subsidies recently, less than a third of the average per-farm subsidy rate in Iowa.[6] But they have a 320-acre farm, which is near the Iowa average of 344 acres. If they received the Iowa per-acre average, their farm would have averaged about $20,837 in subsidies from 1999 to 2001. Jon and Heather didn't get that because they mostly grow grass and hay for their organic, free-range beef herd – grass and hay because that's essential for free-range production and because they want to limit erosion-prone and chemical-hungry crops like corn and soybeans. A few acres of their steepest land are enrolled in the Conservation

Reserve Program, a government programme for keeping the most erodible land out of row crops. They got about $1000 in annual subsidies for that. And they do grow a few acres of corn, plus some wheat and sorghum, both unusual crops for Iowa. They got about $5000 a year for that. But they missed out on an additional $14,837 a year of support that a more conventional operation of their size would have got.

Given that they favour big farms and not agronomic efficiency; given that they encourage overproduction and not soil conservation and environmental protection, in most circumstances; given that they total an awful lot of money devoted to at best dubious outcomes for the public good; given all this, many have long proposed the restructuring of farm subsidies. At the time of this writing, there is considerable hope among those concerned about sustainability that we may have just taken a large step in the right direction with the passage in 2002 (and the partial funding in 2003) of the Conservation Security Program (CSP). This hotly contested title in the 2002 Farm Bill would pay farmers for a whole series of green enhancements to their operations, from building soil-control structures to encouraging wildlife. It's a manifestation of what some observers of agriculture call 'multifunctionality' – the idea that the purpose of agriculture should go beyond the single-minded one of ever-increasing food production. Rather than paying farmers to do only that, through our food expenditures and through the structure of subsidies, we should pay farmers to do some important things that are not directly included in the price of food – things like conserving soil and providing wildlife habitat. The CSP program would pay individual farms up to $45,000 a year to green their operations, based on a tiered system with three levels of enhancements. The CSP, many people hope, is the breakthrough in farm structure that sustainable farmers have been waiting for.[7]

But others are not so optimistic. The CSP's structure turns out to be very complex. Many of the small farmers who have looked into it have despaired of keeping up with the paperwork necessary to sign up for the programme and to document compliance with it. Larger farms are more likely to be able to hire outside help to sort through its tangle of rules. Also, at this writing it is not clear that the programme will receive anything like the level of funding that was originally envisioned for it. Although a farm could conceivably get as much as $45,000 a year in support, on a per-acre basis the programme would pay no more than $22.25 an acre, with full implementation at the level of the third tier – considerably less than farmers have been receiving recently for leaving their land in corn. There is also concern about how green some of the practices the CSP will pay for really are, in part because the rules are still up in the air. Although it will probably on the whole encourage greener practices on the farms that are able to cope with its paperwork requirements, it is too soon to say if the CSP will significantly increase survival rates among sustainable farms.

Another factor that may depress sustainable farm survival rates comes, paradoxically, from a strength of PFI's get-along-but-don't-go-along approach. A farmer who has tried to seat his or her self on the tractor seat of the Big Ag monologue is also likely to be a farmer with a more unitary understanding of his or her self. The more dialogic self of a more dialogic knowledge cultivation, like PFI's, is a more multidimensional self, more accustomed to taking others into consideration and thus to envisioning what other selves might be like, including one's own self. While sustainable farmers may show no less commitment to being a farmer, to getting back on to that horse and to staying on it, they are also possibly more ready to consider other commitments when they find themselves slipping from the saddle once again. With a more open sense of who they are, they may be more ready to accept the outcomes of economic and other structural difficulties because they have come to see their senses of self as less dependent on those structures. They may be more ready to follow a path of self-reinvention, like one male PFI livestock and grain farmer who recently left farming to become a nurse.

But many of these points on the survival rates of sustainable farmers are at best informed conjecture. What we do know is that many PFI farms are prospering, perhaps as well as can be expected in such a high-risk, low-return endeavour as farming. We also know that other farmers are not exactly switching to sustainable practices with great alacrity. It is perhaps a steady trend, but it is still a slow one.

'I'm going to change the question a little bit about issues,' said Donna, moving on to one of our standard questions. 'What do you think are the most important issues facing farming today? The important issues facing rural families in America, even the world?'

'That's a tough one. I don't know where to start.' Brad paused to collect his thoughts. It was one of those open-ended questions that is so broad one hardly knows what to say at first.

'One issue revolves around the polarization that's taking place,' Brad said finally. 'Where out in rural America, maybe for all of America, for that matter, the extremes have the loudest voice. Extremes on both sides. In agriculture, it's the farmers that are getting bigger all the time. It's the corporate aspects of farming that are getting bigger, especially with hogs now. And then the other side is still those of us that are choosing to farm much differently, and trying to sell our food more directly to the consumer. And so you got that group versus the corporate type of farmer.'

Donna nodded and thought about saying something, but decided to stay quiet and let Brad's words tumble out more of their own accord. Meanwhile, Brad hesitated, perhaps to consider where he had got to, and perhaps to wonder if he felt right about calling his own side of farming as much of an 'extreme' as corporate farming. In any event, he clearly was concerned about monologic interactions between the two sides, each 'versus' the other, competing to be the 'loudest voice'.

'And then you got the rest,' he continued. 'Most of us are still caught in the middle yet, trying to figure out just where in the heck are we going.'

'Right,' said Donna supportively.

'It's just such a critical time, I think, for family farm agriculture. 'Cause I think we do have the opportunity to form networks and marketing groups and so forth, so that we can survive. But that's going to have to happen in the next five to ten years, or the opportunities will be gone. Then I think the other, the tremendous hurdle, is education of consumers and citizens in general about the value of farming the way we do.'

In other words, unless the dialogue of practical agriculture widens well beyond its current confines, the cultivation of broad agricultural sustainability is unlikely to come to pass anytime soon. As Brad noted, part of that broadening has to take place among farmers and others in the farming community, such as university researchers, government officials, bankers, agricultural implement dealers, agricultural implement makers, seed suppliers and commodity groups like the Iowa Corn Growers Association. Although Brad rightly worries that there is still much polarization here, much of the success of PFI has been exactly in its ability to invite the participation of others in the farming community into its conversations, into its knowledge cultivation, through the attractions of the group's dialogic approach. PFI has had the greatest impact on its local state university, Iowa State. It can be no accident that Iowa State in 1989 established the Leopold Center for Sustainable Agriculture, which is widely recognized as one of the nation's leading research and extension centres in sustainable agriculture. It can be no accident that in the fall of 2001 Iowa State University enrolled students in the nation's first graduate programme in sustainable agriculture.[8] PFI has also made connections with many of Iowa's traditional agricultural organizations, such as the Iowa Farm Bureau, with which it jointly hosts a series of field days every year to farms that are implementing sustainable practices. At its 2003 annual meeting, PFI hosted a session, led by a rural banker, on the role of bankers in sustainable agriculture. PFI understands what I earlier called the 'wonderful' quality of dialogue: that the inclusion of each additional voice in a dialogue encourages consideration of whomever else is missing, leading to the even greater widening of participation.

But Brad also pointed to another, equally important dimension of broadening the dialogue of practical agriculture: the 'tremendous hurdle', as he put it, of involving those who eat and use what farmers produce in the discussion over what agriculture has become and what it could instead be.

To overcome that hurdle, to encourage the broader relevance of agriculture, we will have to consider the arguments for why agriculture is irrelevant. I think we can divide these arguments into three general sorts, what we might call the *emptying* of agriculture, the *swamping* of agriculture, and the *obsolescence* of agriculture. All three of these arguments, I believe, are misleading.

The emptying of agriculture is probably the most familiar of the three, and it goes like this. Ours is now an urban world. Some 75 per cent of Americans live in urban areas, and 25 per cent in rural areas, the reverse of how things stood 100 years ago. True, worldwide, some 53 per cent of the human population remains rural.[9] Each year, however, the rural percentage drops, as more and more of the human more and more find their fortunes where the real fortunes seem always to be made: in cities. And those who remain in rural areas, particularly in the wealthy countries, are increasingly apt to take up pursuits similar to those of their city cousins – factory work, retail sales, government services. Moreover, rural people in rich countries and poor increasingly commute to urban areas for work. Hardly any rural people actually still farm, at least in the rich countries. In the US, farmers and farm workers are down to a couple of per cent of the workforce of the entire country.[10] Even in Iowa, where agriculture is a larger part of the economy than in any other state, farmers and farm workers account for only about 6 per cent of the employed workforce.[11]

The swamping of agriculture is a related point, although the direction of the argument runs the other way. It suggests that as people have left farms for the city, the forces of the city have taken over the farms. There is nothing special about agriculture anymore. It is an industry like any other, and a business like any other, too. In the words of the rural sociologist William Friedland, 'what is now called "agriculture" has become mostly sets of industrial processes physically located in the open air rather than under a roof.' Agriculture has been 'transformed beyond recognition,' Friedland says.[12] Increasingly, agriculture is a bad neighbour that local residents protest because of its pollution, just like a factory. And with the coming of 'pharming', in which what is grown is not food but bioengineered medicines, agriculture is no longer 'just like a factory'; it is a factory. There is no room here for any sentiment concerning community ties among rural residents, or between rural and urban residents. Agriculture is just a form of capitalism. Indeed, there is no reason even to call it agriculture anymore, suggests Friedland, as what we think that word means no longer exists.

Besides, as the agricultural economist Stephen C. Blank argues in *The End of Agriculture in the American Portfolio*, we don't really need agriculture anymore. Agriculture is obsolete. That's why there's no money in it, and that's why farmers are in such decline. Only a few consumers are willing to spend for their food what it would take to provide American farmers with a decent standard of living. 'In the simplest terms, the production of food and other agricultural products will disappear from the United States because it will become unprofitable to tie up resources in farming and ranching,' Blank argues. Although 'many of them will not believe it at the time,' he continues, many farmers 'will, in a number of ways, be better off after they make the difficult decision to leave agriculture voluntarily.' Good riddance to the high labour, high risk, high capital and low profit of farming. 'We need to strip away the romance and nostalgia surrounding agriculture and see it for what it is: a business,' Blank writes. 'We must learn to let go of farming and ranching.'[13] We won't starve. Farmers in developing countries, with their lower wages and lighter environmental regulations, will be able to export plenty of cheap food to us, Blank argues. And as long as there is plenty of edible goo for us to microwave up whenever we require it, why should we care?[14]

Now, it must be said that there is some truth to these three arguments for the irrelevance of agriculture in the US and other developed countries. More people do live in cities today, almost three-quarters of the developed world. The rural people that remain lead lives that are indeed much the same as those of urban folk, albeit with perhaps a bit more driving (or perhaps not, given the length of some urban commutes). We must admit that much of agriculture, if not most of it, hardly seems like farming anymore. To repeat the sociologist Paul Lasley's phrase, agriculture is increasingly just Ag-ag business, ag chemicals, ag machinery, and perhaps just plain agony for some, given the stress, the struggle, the loss of economic control, the loss of community, the loss of environment, the loss of culture. Also, the US has for many years been the world's largest food importer.[15] We are wealthy enough that we could probably easily import more, if need be.

For many, these trends are to be decried and resisted, lest we truly lose the real meaning of agriculture and the close interaction with communities natural and human that it affords and preserves. Indeed, this book might be read as such a decrying and resisting. And in a way it is. But in a way it isn't, for I believe that some of the concern to save agriculture is misplaced.[16] To decry and resist the 'emptying', 'swamping', or 'obsolescence' of agriculture is, in some measure, to accept the terms by which these three visions of the end of the agriculture frame our understandings. And to accept the terms of the end-of-agriculture debate, whether pro or con, is to accept an unhelpful presumption: that agriculture is something that farmers do.

As Wendell Berry has written, 'eating is an agricultural act'.[17] To eat is to shape the contours of farmland as effectively as any tractor. What we eat is what we grow. How we eat is how we grow. Why we eat is why we grow, and there are many reasons for eating in addition to attending to the necessary, if generally pleasurable, sustenance of our individual bodies. The pleasures and necessities of eating, as we understand them, may be as much about the connections it makes with other places and other lives as about the filling of the self.

Among those connections are connections to the rural places that yield the bulk of what we eat, and to the people who plant the seeds, tend the plants, and harvest the crop. In this sense, there has been no emptying of agriculture. There is just as large a percentage of people involved in agriculture as there has always been: all of us. There may be fewer farmers, but there are no fewer agriculturalists. Indeed, given the increase in the human population, there are substantially more.

Nor, in this sense, can we say that agriculture has been swamped by the forces of the city. There is nothing non-agricultural about urban living. Without agriculture, there would be no urban living, and indeed little human living of any kind. Agriculture is indeed in many ways much different from what it once was, but that's largely because urban life has become part of it, not because urban life has become a source of agriculture's demise.

Nor is agriculture obsolete. If we were to switch to importing all our food, that would not make agriculture any less a part of the American economic portfolio. We would still be eating, paying for it and shaping the lives of farmers and the land thereby. Those farmers and that land would just be that much further away, making our sense of connection to, and understanding of, eating as an agricultural act that much further away in our minds as well.

For while it is true, as long as we yet eat and live, that agriculture is not over, nor even close to it, it is also true that most of us no longer feel a part of its conversation.

In short, agriculture has largely become monologic. It speaks to us, not with us, and that goes for farmers as much as eaters. And it speaks to us with one logic: cheap food is all we should ask of agriculture. We don't want to pay more than we have to for our food, of course. This much is true. But the single-minded focus on producing vast quantities of food in order to feed the world at low cost keeps us from seeing the full connectedness of the agricultural conversation, the connectedness both between people and between people and the earth.

Among those connections are the implications of the cheap-food monologue for farmers, in both rich countries and poor. In the US, our agricultural subsidies, as we have seen, encourage ever-increasing production, which has the effect of driving down the prices farmers receive, which in turn leads them to try to stay on the treadmill and solve the farmer's problem by increasing their production even more. But although this process is often praised for keeping food costs down, it no longer has much impact on what eaters pay. Currently in the US, about 19 cents of every dollar spent on food goes back to farmers – about $123 billion of the $661 billion American consumers spend on food each year.[18] Decreasing that percentage even further would have little effect on food prices, as it is now such a minor fraction of the food dollar.[19] But it would almost certainly result in fewer farmers on the treadmill.

In fact, we are currently awash in food in the US, and in most other industrialized countries. The situation is so bad that, in order to prop up the prices farmers get, so that they don't all fold at once, we burn corn in our cars in the form of ethanol and we have an aggressive food export policy. In addition to being the world's biggest food importer, the US is the world's biggest food exporter. Which is supposed to help feed the world. But as I have discussed, most American agricultural products are too expensive for any but the relatively wealthy in other countries to purchase, the very people who are already eating pretty well. And in circumstances where American food – grain, primarily – does get to poor regions of the world, it tends to depress prices in those areas below what local farmers can make a living on, putting them out of work and making them even poorer. 'Feeding the world' with American grain is consequently often just a pretty slogan for commodity dumping.

Despite being awash in cheap food at home, there is nonetheless widespread hunger in the US. The US Department of Agriculture categorizes nearly 35 million Americans, including 13 million children, as 'food insecure' – approximately 12.5 per cent of the nation in 2002. Approximately 9.4 million live in households that the USDA classifies as 'hungry' – about 3 per cent of the nation.[20] This hunger persists despite the fact that Americans spend less of their income on food – about 11 per cent – than practically any other industrialized nation. But those are average figures. Poor people need to eat as much as rich people do, and although they cut costs and spend quite a bit less, they still spend a much higher proportion of their income on food. People making between $5000 and $10,000 a year spend about 33 per cent of their after-tax income on food.[21] Also, poor people in the US typically face higher food costs, as supermarkets today typically are located in suburban areas, away from where most poor people live.[22] The solution to hunger is not to increase food production in the US. Rather, it lies in reducing inequality here and abroad, in increasing food production within poor countries, and in protecting the environmental base of food production.

Also, most of us don't need more food. In the US there are perhaps greater health problems from overeating than from undereating, as the recent national discussion of obesity has underscored. We need better food. Given that we don't pay much for food to begin with; given that farmers don't get much of what we do pay; given that we currently spend our subsidies mainly to support high production, with relatively less attention to quality production – given all that, better food should be well within the nation's capabilities, without a significant increase in food costs, if any at all.

And we've been working on it, perhaps most notably through the recent growth in the production of organic food. Once found mainly in the form of tired-looking, expensive veggies in hippie co-ops, organic food is now big business. Some 39 per cent of US consumers report that they use organic products at least occasionally.[23] However, organic products are typically significantly more expensive and generally do not yet deliver on the promise of higher quality food with only a small price increase, or even a price decrease. Nor is organic production necessarily helping very many small farms to stay afloat, as organic increasingly becomes bought up into what the writer Michael Pollan has aptly termed the 'industrial-organic complex'.[24]

The point is, as Patricia Allen and Martin Kovach note, organic 'is simply not enough'.[25] Organic agriculture in itself does little to reconnect eaters with the agricultural conversation. In fact, it can be seen as largely a confirmation of their disconnection. What I mean here is that organic food retailing commonly trades on consumers' growing sense of unease with their disconnection from the agricultural conversation, and their consequent lack of trust in what they eat. Organic certification is narrowly based on production criteria. Buying organic food likely does support environmental protection and probably animal welfare, too, but in itself it has little to do with economic justice and bringing people back into the agricultural conversation. The focus of the organic label and its associated inspection system is on individual consumer health in an untrusting world – on what the sociologist Melanie Dupuis has termed 'not in my body' sensibilities – more than reconnecting eaters with a dialogic, practical agriculture.[26]

We have become used to seeing agriculture as a realm out there in the beyond that we have left behind, physically and culturally. This beyond and behind notion of agriculture envisions it as a space, something that we enter when we leave, or perhaps escape, the sprawling city and the artifice and ambition we sense there. Agriculture now feels distant, something that we rarely see and that little impinges on our daily activities. Agriculture feels like a product line – shall I have the Cortlands or the Fujis or the Granny Smiths? – not a relationship to other humans and the earth. That feeling of the product line is part of the feeling of distance, for disconnection is distance.

So why not bring agriculture back home, to everyone's homes? The pleasures of this connection are what Jack Kloppenburg, John Hendrickson and Steve Stevenson mean when they speak of 'foodshed' thinking. The increasingly globalized food system of today encourages a sense of placeless food. Sure, we might know that in North America oranges come from Florida in the winter and from Brazil in the summer, and it may even say so on the signs in the supermarket produce aisle. But here place is used mainly as a sort of brand. We get little sense of the lives of those who raised, sorted and shipped these oranges. We get little sense of the environmental implications of their methods. They're just oranges, some cheaper, some more expensive; some sweeter, some a bit more dried out. But thinking of the food we eat as flows in a foodshed, like flows of water in a watershed, gives direction to the movement of food, and thus an origin to food in specific places and in the specific lives lived there. Foodshed thinking makes all food homemade, for it connects us to the home places of what we eat.

Foodshed thinking also teaches where we ourselves are. 'The foodshed is a continuous reminder that we are standing in a particular place; not anywhere, but here,' write Kloppenburg, Hendrickson and Stevenson.[27] It leads to what Thomas Lyson has called 'civic agriculture' – a 'locally-based agricultural and food production system that is tightly linked to a community's social and economic development', in Lyson's words.[28] And it is leading to it with a will. Communities across the world, especially in those places where food had become the most placeless, the most monological, are returning to local foods, and the dialogic connections to people and environment that is their sweetest taste. In the United States, we have seen an enormous growth of farmers' markets, farm stands, pick-your-own, community-supported agriculture (CSA) projects, community gardens, community farms, community kitchens, institutional buying of local products, and small-scale food processing. For example, between 1994 and 2002 the number of farmers' markets around the country rose from 1755 to more than 3100, a 77 per cent increase.[29] There are now more than a thousand CSA, or subscription, farms in the United States, with more than a hundred thousand member households.[30] Although they are sometimes threatened by development pressures, the growth of community gardens and community farms has been bringing agriculture right back into the city, making the eaters the growers.[31] People are coming to savour the taste of place and the enjoyments of eating locally, eating seasonally, and eating in ways that support local farmers and local communities.

The point of local agriculture is not that North Americans need to give up tea, coffee and bananas. The point is that, in a food system in which what we eat may come from thousands of miles away and where the typical food item is handled 33 times from field to supermarket shelf, there is abundant room to cut way back on the 'middlemen' so as to give a greater share of the food dollar to farmers, while giving eaters healthier, tastier, more environmentally friendly, community-supporting and quite possibly even cheaper food.[32] And everyone gains a sense of connection, of dialogue between grower and eater.

PFI has been among those groups that have in recent years worked hard to provide that connection and dialogue. Through its Field to Family project, PFI has worked to combine issues of equity and sustainability with local eating and local sourcing of food. PFI instituted a 'healthy food voucher' programme that enabled low-income families to participate in the CSA project the group helps coordinate. PFI has organized local institutions to use local sources of food, such as the campus conference center at Iowa State, which now provides an 'all-Iowa meal' option for organizations that use the facility. PFI regularly conducts cooking classes and nutrition classes so that eaters can regain the skills of healthy and efficient home food preparation. PFI started up a farmers' market in Ames, the city where Iowa State is located and where PFI's own offices are. PFI started an annual youth summer camp centred on sustainable agriculture and sustainable food, and began a gardening and nutrition programme with the Ames Boys and Girls Club.

But perhaps the greatest effort that PFI has made to connect farmers and eaters came in 2002, when its members voted to allow non-farmers to become full voting members of the group. The group still asks people to state on their membership application whether they gain 'a significant part' of their income 'directly from farming in Iowa'. And only those who check this box can serve on the group's board. So it is still at heart a farmers' organization. But anyone can join and vote, and half of the group's roughly 700 members are eaters, not farmers, who have taken up this invitation to engage in the dialogue of what a practical agriculture could look like – this invitation to find a place in the wordshed of the foodshed.

The broad sense of connection underlying foodshed thinking allows us to dispense with another unhelpful presumption about agriculture: that its purpose is only to grow food (and fibre and, I suppose, medicine now). We do want agriculture to grow food for us (and fibre and, perhaps, medicine). But growing food is only one dimension of what I would argue is the purpose of agriculture: *cultivation* – the care and tending of creation, human and non-human, social and ecological. Here I mean cultivation in a way different from but related to how I have used it earlier in this book. Here I mean it not as the relationship between who we are and what we know, as the culture of identity and the identity of culture. I mean cultivation as the culture of the earth, as the husbandry and wifery of life, as farming for us all.

Cultivation, then, is a task not only for those people we have long regarded as the agriculturalists. It is a task not only for farmers. It is a task for everyone. I worry, though, that the image of the farm tends to guide our thinking back to a sense of agriculture as the beyond we left behind. There couldn't be a farm in a city, right? A city couldn't itself be a farm, could it? There is something jarring to the pattern of our imagination here.

Thus I suggest, along with Harriet Friedmann, that we imagine the dominant metaphor of agriculture as that of the garden, the *garden* writ large, for a garden is something that I believe we are more used to understanding as potentially everywhere, in city and countryside alike.[33] We are more used to identifying ourselves as potentially all gardeners than as potentially all farmers. Moreover, there is an intimacy and care associated with gardening, an intimacy and care that Big Ag has, to a

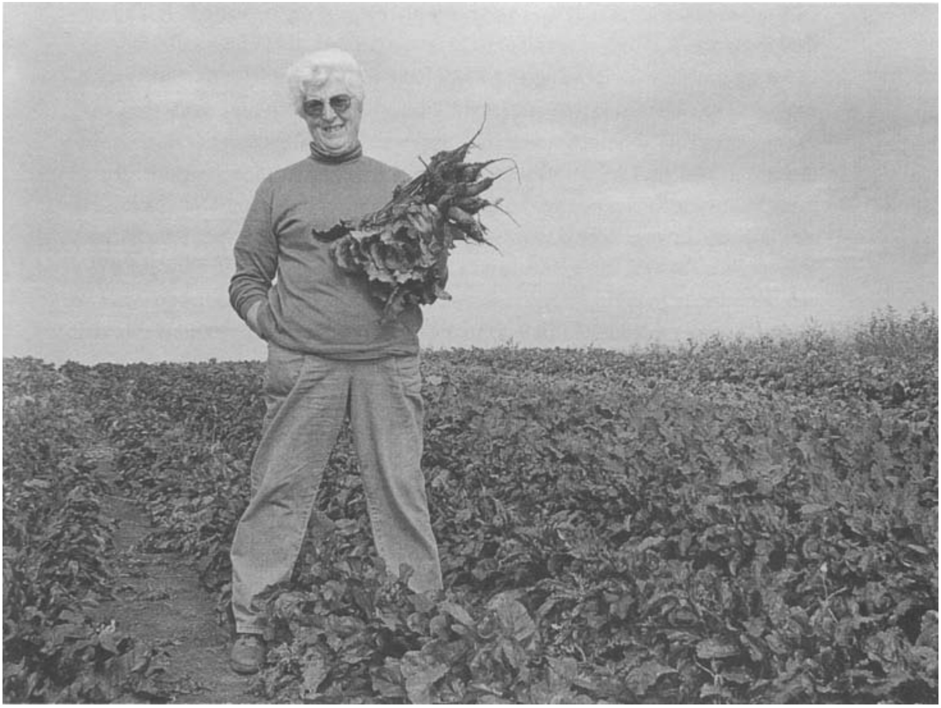

Figure 20.2 *Virginia Moser, PFI member, at the CSA farm she operates with her husband, Marion Moser, 1999*

large extent, driven out of our image of farming. And indeed most farms today do not feel remotely like gardens. Nor do most of our towns and cities, our schools and neighbourhoods, our workplaces and our public life, at least not much of the time. These too are increasingly a form of Big Ag, farming us all, not farming for us all.

So let us put the culture back in agriculture of all forms and in all places. Let cultivation of what Friedmann has termed the 'gardens of Gaia' become our understanding of what the rural is and what farming should be – of what we sometimes succeed in and so often fail to attain in actual social and ecological life in both country and city.[34] To speak of agriculture, then, in this ideal sense, is to consider the degree to which a state of mind and action brings out, or fails to bring out, the gardener's capacity of care for creation.

Which brings us back to dialogue and sustainability. It is something of a romance, I freely confess, to consider agriculture as cultivation in this largest sense, as care of the earth. But it is a romance that allows us to appreciate how the current structures of production so overwhelm our better intentions for the cultivation of the garden. It is a romance with material consequences. It is a practical romance. But only if we all engage in the conversation of agriculture.

For we probably do not all agree about what it means to care for the earth and its ecological and social creation. And that is fine. More than that: it is great – as long as we engage our differences and take responsibility for response ability, for difference is creativity's own unfinalizable wellspring. By coming to imagine agriculture as here and now, wherever we are, and not beyond and behind, we ask for and welcome that engagement. Eaters, growers, purveyors, teachers, builders, doctors, lawyers, bus drivers, factory workers, scientists, even realtors and regulators: we are all potentially agriculturalists in the sense of the gardening of creation. It depends upon our state of mind and action, upon how we contribute to this task that is, thankfully, larger than any of us.

This, I believe, is the practical message of Practical Farmers of Iowa: that cultivation in the agricultural sense depends upon an approach to cultivation in the social sense that embraces the creativity of difference, openness and the unfinalizable. A dialogic, practical agriculture requires that we all consider agriculture a central feature of everyone's lives, worthy of everyone's care and careful attention. A dialogic, practical agriculture requires that we sustain the broadest possible conversation about agriculture. For what Iowa's practical farmers are really trying to farm is democracy, the democracy of the people's good earth. The same is true of practical farmers everywhere. They are all guided by a common insight: that farming for us all, in every field of human endeavour, is only possible when there is farming by us all.

Acknowledgements

As I sit down to write these acknowledgements, the autumnal equinox fast approaches and the harvest is on in the Midwest. It's a time for finishing up, for gathering together, for putting things away, for reflecting on the season past. As day and night near equality, it's a time for assessing the balance of things. And it's a time for giving thanks.

Harvest and the equinox thus seems to me a very good time to write the acknowledgments for a book long in cultivation, perhaps especially for a book about farming. When the crop is full ripe (or as ripe as it's going to get), it needs to be gathered together. And so it is with the crop of this book. It is time to finish up. It is time to reflect on the season past and to give thanks for those who have contributed so much to its fruits.

A common myth – there can be no other word for it – is that the real farmer farms alone, toiling single-handedly against the elements, and that every farm has only one farmer. He (in the myth it almost always is a he) is the farmer. The others are farm workers, farmhands, farm wives, farm kids. The members of Practical Farmers of Iowa and other sustainable agriculture groups, as this chapter describes, are struggling to overcome this singular understanding of the authorship of a farm, as part of their efforts to create a more dialogic, and thus more practical, agriculture. We need also to struggle against the parallel myth of the single authorship of a book. No author truly works alone. No book truly has just one author.

This is particularly true of a book such as this one. Central to whatever fruit this book can be said to offer are the participatory methods with which the underlying research was conducted. Without Donna Bauer and Sue Jarnagin of Practical Farmers of Iowa and their on-the-ground insights, and without Greg Peter's master's thesis work, this book would have been not only less informed, less intelligent, less relevant, less valid and reliable a witness of the conditions of farming today – to the extent it has any of these good qualities – it would have been a whole lot less fun. To them I owe the biggest thanks.

Notes

1 Dick describes this experience as follows in Thompson, Thompson and Thompson (2002, p1–3): 'Several years ago while cleaning out a hog waterer, Dick heard a voice that said, "Get along but don't go along." There was no other person around at the time. This concept is what we are supposed to do. We don't have to convict or convince anybody, just share when asked. This makes the yoke easier and the burden lighter. This policy has left the door open to go to many land grant universities in the United States and overseas during the last few years.'

2 This is also in keeping with what I have elsewhere termed the 'dialogue of solidarities' (Bell, 1998).

3 Three members I asked said they thought survival rates of sustainable and conventional farms were about the same. A couple thought the rate was slightly higher for sustainable farms.

4 Environmental Working Group (2002) figures, divided by the 96,000 farms the US Agricultural Statistics Service recorded for Iowa in 1999. Anthan (2001) reports considerably higher subsidy figures, but the Environmental Working Group is more reliable.

5 Environmental Working Group (2002).

6 I looked up their subsidy on the internet, courtesy of the Environmental Working Group, www.ewg.org, which has usefully posted the subsidy figures for every farmer in the US.

7 See, for example, the website of the Minnesota Project, a nonprofit Minnesota environmental group, www.mnproject.org/csp/.

8 I make this observation with some caution, as I was myself involved in establishing this programme. Thus readers should take into consideration that I may have some personal interest in promoting its significance.

9 Figure for 1999 (United Nations Population Fund, 1999).

10 The precise figure of Iowa farms that raise livestock, as of the 1997 agricultural census, was 57 per cent (National Agricultural Statistics Service, 1999, Table 2). However, the number is dropping fast. Many thousands of hog farmers gave up during the steep price dip during the winter of 1998–1999, and thus the percentage of Iowa farms with livestock now is probably below 50 per cent.

11 Based on dividing the number of farms in Iowa in 2002 (92,500, according to the Iowa Office of the National Agricultural Statistics Service, 2003) by the size of the employed labour force in the state (1,560,300, according to Iowa Workforce Development, 2003), one gets a higher figure than the slightly less than 5 per cent I earlier derived from Otto, Swenson and Immerman (1997), to which I have added a per cent or so for farm workers.

12 Friedland (2002, pp352, 368).

13 Blank (1998, pp1, 3, 193, 195).

14 I'm adapting a line here from the Iowa State University agricultural economist Mike Duffy (personal communication), who certainly is no fan of food as edible goo.

15 It is also the world's largest food exporter, a point that Blank does not consider closely.

16 For examples of the Jeffersonian view that I wish to sidestep, see Comstock (1986).

17 Berry (1990, p145).
18 Figures for 2000, from USDA Economic Research Service (2003).
19 I thank Mike Duffy for this observation.
20 Nord, Andrews and Carlson (2003).
21 Blisard (2001, table 19).
22 Kaufman et al (1997).
23 Organic Trade Association (2003), citing a Natural Marketing Institute 2002 study.
24 Pollan (2001).
25 Allen and Kovach (2000).
26 Dupuis (2000).
27 Kloppenburg, Hendrickson and Stevenson (1996, p41).
28 Lyson (2000, p42).
29 Lyson (2000, p45), and US Department of Agriculture (2002).
30 Several websites, including several USDA websites, attribute this figure to a 1999 USDA study, but I was not able to locate the original source.
31 In perhaps the most dramatic example of the development of urban agriculture, some neighbourhoods in Cuban cities now raise some 30 per cent of their food locally. See Funes et al (2002).
32 The figure of 33 times is from Kahn and McAlister (1997).
33 Friedmann (2003).
34 Ibid.

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VOLUME II

AGRICULTURE AND THE ENVIRONMENT

EDITED BY

JULES PRETTY

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Sustainable Agriculture and Food

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List of Acronyms and Abbreviations

ABE/GED	Adult Basic Education/General Education Development
AAD	Agro-ecosystem Analysis and Development
ACORN	Association of Community Organizations for Reform Now
APCSA	Ecuadorian Association for the Protection of Crops and Animal Health (now Crop Life Ecuador)
BMDC	Blue Mound Development Corporation
BMSC	Blue Mound Store Corporation
BPH	brown planthopper (of rice)
BSE	bovine spongiform encephalopathy
CAFO	concentrated animal feeding operation
CAP	Common Agricultural Policy (EC)
CAS	Chinese Academy of Sciences
CAST	Council for Agricultural Science and Technology
CDC	Centers for Disease Control and Prevention
CDC	Community Development Corporation
CGIAR	Consultative Group on International Agricultural Research
CIAT	Cantro Internacional de Agricultura Tropical
CIP	International Potato Center
CJD	Creutzfeld–Jakob Disease
CRP	Conservation Reserve Program
EA	Environment Agency (UK)
EEC	European Economic Commission
ERS	Economic Research Service
EU-FAO IPM	European Union-Food and Agriculture Organisation Integrated Pest Management
EU	European Union
FAO	Food and Agriculture Organization (UN)
FEMA	Federal Emergency Management Agency
FFS	Farmer Field School
FIC	farmer innovation circles
FSIS	Food Safety and Inspection Service
HACCP	Hazard Analysis and Critical Control Point
HCN	household communication networks
HIC	household innovation capacity
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics

IESWTR	Interim Enhanced Surface Water Treatment Rule
INIAP	National Institute of Agricultural Research from Ecuador
IPM	Integrated Pest Management
IPPM	Integrated Production and Pest Management
IRRI	International Rice Research Institute
JFM	joint forest management
KFTC	Kentuckians for the Commonwealth
LDC	less developed country
LSD	least significant difference
LSP	Land Stewardship Project
MRL	maximum residue levels
NAO	National Audit Office
NGO	non-governmental organization
NRM	natural resource management
OP	organophosphate
OPM	organic pest management
OTA	Office of Technology Assessment
PPE	personal protective equipment
RCCI	Rural Community College Initiative
RHTs	resource and habitat taboos
S&S	signs and symptoms
SDWA	Safe Drinking Water Act
SESA	Ecuadorian Plant and Animal Health Service
SOCM	Save Our Cumberland Mountains
SRI	System of Rice Intensification
SUP	safe use of pesticides
TOA	Trade-off Analysis
ToF	Training of Facilitators
UN	United Nations
USACE	US Army Corps of Engineers
USDA	US Department of Agriculture
WED	Women, Environment and Development
WHO	World Health Organization
WTAC	willingness to accept compensation
WTP	willingness to pay

Editorial Introduction to Volume II

Jules Pretty

The Real Costs

When we buy or bake our daily bread, do we ever wonder about how much it really costs? We like it when our food is cheap, and complain when prices rise. Indeed, riots over food prices date back at least to Roman times. Governments have long since intervened to keep food cheap in the shops, and tell consumers that policies designed to do exactly this are succeeding. In most industrialized countries, the proportion of the average household budget spent on food has been declining in recent decades. Food is getting cheaper relative to other goods, and many believe that this must benefit everyone as all need to eat food. Food is not cheap. It only appears cheap in the shop because consumers are not encouraged to think of the hidden costs of damage caused to the environment and human health by certain systems of agricultural production.

Thus consumers actually pay three times for their food. Once at the till in the shop, a second time through taxes that are used to subsidize farmers or support agricultural development, and a third time to clean up the environmental and health side effects. Food looks cheap because these costs are only accounted for elsewhere in the economy. The real costs are thus not internalized in prices. On the cheapness of food, Donald Worster recognized this in his *The Wealth of Nature* (1994): 'the farm experts merely assume, on the basis of marketplace behaviour, that the public wants cheapness above all else. Cheapness, of course, is supposed to require abundance, and abundance is supposed to come from greater economies of scale, more concentrated economic organisation, and more industrialised methods. The entire basis for that assumption collapses if the marketplace is a poor or imperfect reflector of what people want.'

This is not to say that prices in the shop should necessarily rise, as this would penalize the poor over the wealthy. Using taxes to raise money to support agricultural development is also potentially progressive, as the rich pay proportionally more in taxes, and the poor, who spend proportionally more of their budget on food, benefit if prices stay low. But this idea of fairness falters when set against the massive distortions brought about by modern agricultural systems that additionally impose large environmental and health costs throughout economies. Other people and institutions pay for these costs, and this is both unfair and inefficient. If it were possible to add up the real costs of producing food, we would find that modern industrialized systems of production perform poorly in comparison with sustainable systems. This is because we permit cost-shifting – the costs of ill health, lost biodiversity and water pollution are transferred away from farmers, and so not paid by those producing the food nor included in the price of the products sold. Until recently, though, we have lacked the methods to put a price on these side effects.

When we conceive of agriculture as more than simply a food factory, indeed as a multifunctional activity with many side effects, then the idea that farmers do only one thing must change. Of course, it was not always like this. It is modern agriculture that has brought a narrow view of farming. The rural environment suffers as environmental services are affected, the food we eat is as likely to do as much harm as good, and we still think food is cheap. The external costs and benefits of agriculture raise important policy questions. In particular, should farmers receive public support for the public benefits (environmental and health services) they produce in addition to food? Should those that pollute have to pay for restoring the environment and human health? These two principles are called 'the provider gets' and 'the polluter pays', and they are important for both industrialized and developing countries. Three categories of policy instruments are available: advisory and institutional measures, regulatory and legal measures, and economic instruments. Effective pollution control and the supply of desired public goods requires a mix of all three approaches, together with integration across sectors.

A range of policy reforms could do much to internalize some of these costs and benefits in prices. In practice, as no single solution is likely to suffice, the key issue rests on how policy makers choose an appropriate mix of solutions, how these are integrated, and how farmers, consumers and other stakeholders are involved in the process of reform itself. Attention will therefore need to be paid to the social and institutional processes that both encourage farmers to work and learn together, and result in integrated cross-sectoral partnerships. Policy integration is vital, yet most policies seeking to link agriculture with more environmentally-sensitive management are still highly fragmented.

One problem is that many environmental policies have tended only to green the edges of farming. Thus an essentially modernist agriculture remains much as it ever was, but is now light green. Many non-crop habitats have been improved, including hedges, woodlands and wetlands. But the food is still largely produced in a conventional manner. The bigger challenge is to find ways of substantially greening the middle of farming – in the field as well as around the edges. A thriving and sustainable agriculture requires both integrated action by farmers and communities, and integrated action by policy makers and planners. This implies both horizontal integration with better linkages between sectors, and vertical integration with better linkages from the micro to the macro level. Most policy initiatives remain piecemeal, affecting only a small part of farmers' practices, and so do not yet lead to substantial shifts towards sustainability.

Part 1: Agricultural Harm to the Environment

The first paper is the iconic opening chapter to Rachel Carson's *Silent Spring*. It is just two pages in length, and is entitled *A Fable for Tomorrow*. Written in the early 1960s, and later to influence generations of scientists, consumers and policy makers, it is a story of modern society and the consequences of environmental and social decay. It is told as a fable, which is clever. It does not seek to be analytical or specific to one set of circumstances. The fable generalizes, and so must be inaccurate about certain places. But its very nature captures attention, and shows how Carson was so influential. It starts, 'there was once a town in the heart of America', and describes its checkerboard of prosperous farms, with oak and maple and birch, and foxes barking in the hills. Fish swum in the streams that flowed clear and cold out of the hills. But 'then a strange blight crept over the area, and everything began to change'. Some evil spirit settled on the community, and no one knew why. There was a strange stillness. The birds were silent: 'it was a spring without voices'. The tragedy is, of course, that 'the people had done it themselves' with their adoption of modern agricultural methods.

In the second article, an excerpt from the 2002 book, *Agri-Culture*, Jules Pretty indicates that the real costs of food are much higher than the price paid in the shop. Environmental externalities and the diversion of tax revenue to subsidize agriculture contribute to the real cost. Agriculture, like any economic sector, has both negative and positive side effects, and it is the movement towards a more multifunctional view of agriculture that could result in a better understanding of what contributes to agricultural sustainability. This paper summarizes the first study of the full costs of a national agricultural sector. In the UK, these amounted to some £1.5 billion per year during the 1990s. These external costs are alarming – and should call into question what is meant by efficiency. Increased sustainability in agricultural systems can only happen if these external costs are substantially reduced.

In the third paper, Erin Tegtmeier and Michael Duffy analyse the full cost of modern agricultural production in the US. These are of the order of $5.6–16.9 billion per year (in 2002 $), arising from damage to water resources, soils, air, wildlife and biodiversity, and harm to human health. Additional annual costs of $3.7 billion arise from agency costs associated with programmes to address these problems or encourage a transition towards more sustainable systems. Following various partial studies published in the 1990s, this was the first study of the costs of the whole of the agricultural sector in the US. As the authors indicate, 'many in the US pride themselves on our cheap food. But this study demonstrates that consumers pay for food well beyond the grocery store.'

The fourth article by Steve Sherwood and co-authors is a chapter drawn from the 2005 book, *The Pesticide Detox*. It focuses on pesticide use and its effects in the highland region of Carchi in the northern Andes. Farmers use a wide range of pesticides, both hazardous and benign, and although local and international businesses indicate that highly toxic products can be used safely, the evidence from the ground is different. This study found that poisonings in Carchi are amongst the highest recorded in the world – an annual rate of 171 per 100,000 population for morbidity, and 21 per 100,000 for mortalities. Pesticides were found on family clothing, on food and in children's bedding. To illustrate these pathways to local people, the researchers added fluorescent dyes to pesticides, and then used UV lights to show their presence. The challenge, now, is to develop new ways of learning about pests and diseases in such rural communities, as well as to develop agricultural practices that reduce dependency on those pesticides that are harmful to humans and the environment.

Although some pesticides are known to be harmful to people, there are surprisingly few empirical studies that analyse their effects. At the global level, the World Health Organization (WHO) can only estimate very broadly the number of farmers, families and consumers who might be affected. This paper by Francesca Mancini and colleagues makes an important contribution to knowledge by conducting a season long assessment of acute pesticide poisoning in three villages of Andhra Pradesh in India. An average of 20 pesticide applications are made per season on cotton. Some 323 adverse events were reported amongst both men (who apply the pesticides in the fields) and women (who mix products and refill spray tanks). More than 80 per cent of the events were associated with signs of mild to severe poisoning; and 10 per cent of pesticide application sessions caused three or more neurotoxic symptoms associated with organophosphate products. Although 6 per cent of the spray sessions caused severe neurotoxic effects, no farmers or workers sought medical care. Low income, marginal farmers were more often subjected to severe poisoning than landlords. The paper concludes by indicating that Integrated Pest Management (IPM) methods that reduce the health burden on local people should be pursued.

Part 2: Agroecology and Sustainability

Agroecosystems are ecological systems modified by humans to produce food, fibre or other agricultural products. This classic paper by Gordon Conway discusses the boundaries and components of agroecosystems, which can be regarded as true cybernetic systems whose goal is increased social value. Agroecosystems exist in a hierarchy from plant-environment to field, farming system, watershed and so on, and systems theory indicates that the behaviour of higher level systems cannot readily be discovered from a study of lower systems, and vice versa. This paper makes a significant contribution by indicating that agroecosystems have four key properties: productivity, stability, sustainability and equitability. Agricultural development inevitably involves making trade-offs between these properties. The four properties are linked to one another, both within an agroecosystem and between agroecosystems at different levels in a hierarchy. The trade-offs can be seen clearly in the history of agriculture, and this paper describes four key examples: the origins of agriculture, involving the domestication of wild cereals to increase stability but not necessarily, at first, to increase productivity; manorial agriculture of the British Middle Ages; modern western agriculture; and the green revolution in Indonesia. The paper ends by suggesting the need for practical analytical tools and development packages that emphasise multidisciplinary approaches, such as agroecosystem analysis.

The second article by Carl Folke and colleagues analyses the characteristics of social-ecological systems. They seek to provide a rich understanding of not just human–environment interactions but of how the world we live in actually works and the implications it has for current policies and governance. The chapter emphasizes that the social landscape should be approached as carefully as the ecological in order to clarify features that contribute to the resilience of social-ecological systems. These include vision, leadership and trust; enabling legislation that creates social space for ecosystem management; funds for responding to environmental change and for remedial action; capacity for monitoring and responding to environmental feedback; information flow through social networks; the combination of various sources of information and knowledge; sense-making and arenas of collaborative learning for ecosystem management. Their work illustrates that the interplay between individuals (e.g. leadership, teams, actor groups), the emergence of nested organizational structures, institutional dynamics, and power relations tied together in dynamic social networks are examples of features that seem critical in adaptive governance that allows for ecosystem management and for responding to environmental feedback across scales. They conclude that the existence of transformative capacity is essential in order to create social-ecological systems with the capability to manage ecosystems sustainably for human well-being. Adaptive capacity will be needed to strengthen and sustain such systems in the face of external drivers and events.

The third article by Stephen Gliessman is an overview of agroecological approaches to the management of agricultural systems. As he indicates, 'discussions about sustainable agriculture must go beyond what happens within the fences of any individual farm'. It is the wider environmental, economic and social interactions that are critical. A practising farmer as well distinguished academic, Gliessman draws on a wide range of experience to set out an agroecological perspective to the flows of energy and nutrients in agroecosystems, and identifies the population regulating mechanisms and potential for developing dynamic equilibira. The paper includes a table that summarizes the guiding principles for a process of design of and conversion to sustainable agricultural systems. Comparisons are made between traditional, conventional (or modern) and sustainable systems. This question of redesign is critical if different patterns of agricultural and environmental management are to emerge, patterns that are able to produce both food and important environmental services.

In the fourth article, Kevin Gallagher and co-authors describe the ecological and social basis for IPM in rice agroecosystems in Asia. The chapter, drawn from the book *The Pesticide Detox*, first sets out the specific ecological basis of rice fields, and why continued pesticide applications have not resulted in cheap and effective pest control. Pesticides may kill pests in the short term, but they also eliminate natural enemies that exert good ecological control over pests. The idea behind IPM is to put technologies into the hands of farmers and communities, so that they learn to farm with low to zero use of pesticides, yet also do not suffer pest losses. Many tens of thousands of farmer field schools have been held throughout Asia, and these have been highly effective at increasing farmers' own capabilities and knowledge for ecological management of rice fields. Many countries are now reporting large reductions in pesticide use. In Vietnam, two million farmers have cut pesticide usage from more than three sprays to one per season; in Sri Lanka, 55,000 farmers have reduced usage from three to a half per season; and in Indonesia, one million farmers have cut usage from three sprays to one per season. In no case has reduced pesticide use led to lower rice yields. Amongst these are reports that many farmers are now able to grow rice entirely without pesticides: a quarter of field school trained farmers in Indonesia, a fifth to a third in the Mekong Delta of Vietnam, and three-quarters in parts of the Philippines.

In the final article, Dana Jackson of the Land Stewardship Project describes the way that farms can be developed as part of natural habitats. As she says, 'it's hard to imagine what it must have looked like when Europeans first settled the midwest, when it was a wilderness with prairie, forest, clean streams and herds of buffalo. Too quickly it became dominated by agriculture.' The remaining wildlands are preserved and protected in parks and reserves, but that leaves the great majority of land directly shaped by the business of food production. Jackson introduces an alternative vision for this agriculture that is inspired by Aldo Leopold, and which indicates that farming and natural areas should be interspersed, not separated. There are many benefits of thinking differently – the benefits of biodiversity for farming itself, and the effects of more sustainable farming on biodiversity. We must teach, as Jackson says, that 'the land is one organism'.

Part 3: Communities and Social Capital

In the first article, Mary Mellor sets out the case for a deep materialist perspective on feminism and environmental ethics. Unlike some other writers, she does not claim that women have a superior vision, or higher moral authority, but indicates that an ethics that does not take account of the gendered nature of society is doomed to failure, as it will not confront the structure of society and how that structure impacts on the material relationship between humanity and nature. Mellor helpfully summarizes a number of traditions, from feminism and environmental ethics, to eco-feminism, materialist feminism, mediation in human–nature relations, deep materialism, ecological holism, and immanent realism. She argues 'that the politics of human–nature relations is critical. There is no natural balance in nature, and so any form of sustainable connectedness would need to be created through human reason and political action.' The problem, of course, is how political change can occur. Should it be driven from the top, or does political agency need to come from people and groups who are exploited, marginalized and excluded by the existing social and ecological structures? Mellow indicates that 'building coalitions and coordinated political action are essential'. The basis for this position is that knowledge about the natural world will always be partial, and so 'awareness of the radical uncertainty of human immanence should be the starting point of all other knowledge'. Humanity is part of a dynamic iterative ecological process where the whole is always more than the sum of the parts.

It is increasingly well-established that social capital is an important factor in building and maintaining collective action, which is in turn fundamental to substantial and long-term changes in natural resource management. Analysis of causal relationships among improved resource management and collective action has hitherto centred on the existence or creation of appropriate institutional and property arrangements, but there is an emerging recognition that relations of trust and common values are important to collective action. In the second paper, Westerman et al contribute to an improved understanding of the gender aspects of social capital manifested in groups for natural resource management. They investigate how gender differentiated social groups differ in their activities and outcomes for natural resource management. Men's, mixed and women's groups were analysed in 46 rural programmes in 20 countries of Latin America, Africa and Asia. Significant gender differences were found in relation to group maturity and natural resource management achievements and approaches as well as important differences in experiences of collaboration and capacity to manage conflict. Overall they found that collaboration, solidarity and conflict resolution all increase as women's presence in groups increases. In addition, norms of reciprocity are more likely to operate in groups where women are present. Similarly, capacity for self-sustaining collective action increased with women's presence and was significantly higher in the women's groups. The results demonstrate the importance of gender analysis for collective natural resource management and particularly the role of women for collaboration in and the sustainability of natural resource management groups.

In the third article, Jules Pretty sets out the importance of social capital in the collective management of natural resources. The term social capital captures the idea that social bonds and norms are important for people and communities. It emerged as a term following detailed analyses of the effects of social cohesion on regional incomes, civil society and life expectancy. As social capital lowers the transaction costs of working together, it facilitates cooperation. People have the confidence to invest in collective activities, knowing that others will also do so. They are also less likely to engage in unfettered private actions with negative outcomes, such as resource degradation. Four features are important: relations of trust; reciprocity and exchanges; common rules, norms and sanctions; connectedness in networks and groups. Collective resource management programmes that seek to build trust, develop new norms and help form groups have become increasingly common, and are variously described by the terms community-, participatory-, joint-, decentralized-, and co-management. They have been effective in several sectors, including watershed, forest, irrigation, pest, wildlife, fishery, farmers' research, and micro-finance management. Since the early 1990s, some 400,000–500,000 new local groups were established in varying environmental and social contexts, mostly evolving to be of similar small size, typically with 20–30 active members, putting total involvement at some 8–15 million households. The majority show the inclusive characteristics identified as vital for improving community well-being, and evaluations have confirmed that there are positive ecological and economic outcomes, including for watersheds, forests and pest management.

A classic study conducted in 1946 by Walter Goldschmidt showed what happens when the social structure in the countryside changes during modernization. He studied the two rural Californian communities of Arvin and Dinuba in the San Joaquin Valley. These were matched for climate, value of agricultural sales, enterprises, reliance on irrigation, and distance from urban areas. The differences were in farm scale: Dinuba was characterized by small family farms and Arvin by large, commercialized farms. There were striking differences between the two communities. In Dinuba, there was a better quality of life, superior public services and facilities, more parks, more shops and retail trade, more diverse businesses, twice the number of organizations for civic improvement and social recreation, and better participation by the public. A study of the same communities in the late 1970s reaffirmed these findings. Recent years have brought severe financial crises for family farmers, as they were squeezed by debt and low prices. Many thousands lost their businesses. Others, though, did not see this as a problem, but as desirable, as small farmers were widely taken to be economically inefficient. But their loss has been a severe loss to rural society. Linda Lobao's paper shows the importance of the locality that Goldschmidt illustrated. The changing structure of farming has brought about a decline in rural population, increased poverty and income inequality, lower numbers of community services, less democratic participation, decreased retail trade, environmental pollution and greater unemployment. The decline of family farming does not just harm farmers. It hurts the quality of life in the whole of society. Corporate farms are good for productivity, but not much else: 'this type of farming is very limited in what it can do for a community … we need farms that will be viable in the future, correspond to local needs and remain wedded to the community'.

The final paper of this section by Bin Wu and Jules Pretty analyses social connectedness in a marginal rural region of China. Despite remarkable recent achievements, rural poverty still presents significant challenges in China. Poverty is particularly endemic in marginal areas characterized by problems of both poor asset stock (natural, physical and human capital) and the scarcity of capital inflows (e.g. in terms of finance, technology, information and talent). If there is to be a breakthrough for rural development in these marginal areas, then agricultural innovation is widely viewed as a necessary condition. Yet technological innovation is constrained by the difficulties that formal agricultural extension finds in reaching remote and inaccessible areas. This lack of communication and interaction between farmers and agricultural professionals constrains the fit between the supply of new technologies and the pressing needs of the rural poor. Hitherto, most attention has been paid to improvement of development assistance and agricultural extension, rather than assessing the development potential of marginal communities themselves. These are dynamic and diverse, with great potential for innovation in both technologies and self-organization. This paper explores the implications of farmer innovation and local self-organization for government and agricultural professionals. The focus is on rural communities of north Shaanxi in China and the phenomenon of 'farmer innovation circles'. These are informal social systems used by the rural poor for their own technology development and cooperation. The paper explains the theoretical background and analytical framework, then summarizes the features of Zhidan County and methodology used. The distribution of household innovative capacity is then linked to wider innovation circles and household incomes. Overall, the paper shows how innovative capacity is accumulated, and concludes with reflections on the development and policy implications.

Part 4: Ecological Restoration and Design

In the first article of this section, David Orr sets out the components and principles of ecological design and education. Ecological designers know one big thing – everything is hitched to everything else. This suggests a need for a blending of nature with human-crafted space, a bringing together of arts, crafts, science and architecture. But this is easy to say, and hard to achieve. We will need to spend more time thinking about how we see the world, and how we learn from it. A number of key principles are set out for a new type of design that recalibrates education with ecology. Nature is not something to be mastered, but a potential tutor and mentor for human actions. But ecological design is deeper than mimicry. It should encourage us to ask what will nature permit us to do? Another key principle is that humans are not infinitely plastic. There are biological and evolutionary constraints that shape our interactions with the world. All design is, of course, inherently political, as it is about both the provision of goods and services, but also the distribution of risks, costs and benefits. Ecological design implies robust economics, an honest assessment of human capabilities, a capacity to understand the lessons of history and past civilizations, and above all offers opportunities of healing. Designers are storytellers that aim to speak to the human spirit, and this is where education must mimic, and tell better stories about the world.

In the second article, Geoff Gurr et al indicate that ecological restoration methods must also be technically achievable and socially acceptable and spread over a range of locations. Two key aspects of agricultural biodiversity are analysed: the ways in which agricultural biodiversity may be increased to favour pest management, and the existence of a hierarchy of the types of benefits of increased biodiversity. At simple levels, structures in monocultures may be changed with new management practices to benefit natural enemies. At the other extreme, annual and perennial non-crop vegetation may be introduced to affect biodiversity on the farm or even landscape scale. There may be benefits for crop yield and quality, improved sustainability of farms, and broad societal benefits such as for recreation and aesthetics. The potential for ecological restoration of farmland to improve the sustainability of agricultural production whilst conserving biodiversity in farmscapes is high but there is still much to learn, particularly for the most efficient use of agri-environmental schemes to change land use practice.

In the third article, Cornelia Butler Flora and Jan Flora, both of Iowa State University, succinctly set out how social capital can be created in post-industrial rural communities. Two processes are occurring: the inside decay, and the incursion from outside as the suburban and disconnected sprawl brings people with different worldviews and values. Those with affluent incomes can ignore investing in social capital, as they can substitute financial capital – yet this simply results in more goods and services being imported from outside and leaves communities struggling. This article indicates that social capital can be horizontal, hierarchical or non-existent – and different patterns define different outcomes for rural communities. Diverse networks that enhance lateral learning can lead to dynamic communities able to develop new and more sustainable models of agriculture.

In the mid-1990s, one of the authors of the article by Norman Uphoff et al, speaking to the 15th World Congress of Soil Science, proposed that it was time to move soil science toward a 'second paradigm' in order to meet agricultural production needs in the tropics, and indeed in the world more generally. The prevailing paradigm, he noted, focuses primarily on production goals, and little on ecological functions. The new paradigm articulated by Sanchez addressed the particular problems of farmers who are managing marginal lands under a prevailing combination of biophysical and socioeconomic constraints: aluminium toxicity, low nutrient reserves, low water-holding capacity, high phosphorus fixation, steep slopes. For such farmers, the prescriptions of the green revolution, with its reliance on external inputs, were not working. The economic costs and logistical problems involved in procuring fertilizers and agrochemicals were prohibitive, and few of these farmers had access to irrigation, so they were dependent on rainfall with its uncertainties and insufficiencies. External inputs gave little benefit unless the water requirements of the plants and the soil (i.e. the organisms living within it) were met. The emergent 'second paradigm' is described in this final chapter of the book *Biological Approaches to Sustainable Soil Systems*. Its key themes are articulated by Sanchez in this way: 'Rely more on biological processes by adapting germplasm to adverse soil conditions, enhancing soil biological activity, and optimizing nutrient cycling to minimize external inputs and maximize the efficiency of their use.'

In the final article of this volume, North Dakota farmer Fred Kirshenmann begins by setting out the challenge of farming with the wild. As he says, his relationship with the wild has been fraught with ambiguity. He grew up believing that wildernesses would only exist in enclaves apart from agriculture. Yet this dualistic approach to land use is dysfunctional for a variety of reasons. As he says, 'the environment is constantly being constructed by the organisms (including humans) who live in it'. He goes on to describe the importance of wildness in productive farming, in terms of choice of livestock breeds, habitats for pollinators and crop rotations to eliminate herbicides. In the second part of the article, Dan Imhoff sets out the case for farming with the wild, drawing on a wide range of examples across North America. Industrialized agriculture tends to farm against the wild, and is characterized by huge monoculture fields and massive contained livestock operations. The rethinking needed to farm with the wild is already now beginning to happen – the wild farm pioneers are building alliances and developing new ways to reshape farming and food systems.

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Part I

Agricultural Harm to the Environment

1

A Fable for Tomorrow

Rachel Carson

There was once a town in the heart of America where all life seemed to live in harmony with its surroundings. The town lay in the midst of a checkerboard of prosperous farms, with fields of grain and hillsides of orchards where, in spring, white clouds of bloom drifted above the green fields. In autumn, oak and maple and birch set up a blaze of colour that flamed and flickered across a backdrop of pines. Then foxes barked in the hills and deer silently crossed the fields, half hidden in the mists of the autumn mornings.

Along the roads, laurel, viburnum and alder, great ferns and wildflowers delighted the traveller's eye through much of the year. Even in winter the roadsides were places of beauty, where countless birds came to feed on the berries and on the seed heads of the dried weeds rising above the snow. The countryside was, in fact, famous for the abundance and variety of its bird life, and when the flood of migrants was pouring through in spring and autumn people travelled from great distances to observe them. Others came to fish the streams, which flowed clear and cold out of the hills and contained shady pools where trout lay. So it had been from the days many years ago when the first settlers raised their houses, sank their wells and built their barns.

Then a strange blight crept over the area and everything began to change. Some evil spell had settled on the community: mysterious maladies swept the flocks of chickens; the cattle and sheep sickened and died. Everywhere was a shadow of death. The farmers spoke of much illness among their families. In the town the doctors had become more and more puzzled by new kinds of sickness appearing among their patients. There had been several sudden and unexplained deaths, not only among adults but even among children, who would be stricken suddenly while at play and die within a few hours.

There was a strange stillness. The birds, for example – where had they gone? Many people spoke of them, puzzled and disturbed. The feeding stations in the backyards were deserted. The few birds seen anywhere were moribund; they trembled violently and could not fly. It was a spring without voices. On the mornings that had once throbbed with the dawn chorus of robins, catbirds, doves, jays, wrens and scores of other bird voices there was now no sound; only silence lay over the fields and woods and marsh.

On the farms the hens brooded, but no chicks hatched. The farmers complained that they were unable to raise any pigs – the litters were small and the young survived only a few days. The apple trees were coming into bloom but no bees droned among the blossoms, so there was no pollination and there would be no fruit.

The roadsides, once so attractive, were now lined with browned and withered vegetation as though swept by fire. These, too, were silent, deserted by all living things. Even the streams were now lifeless. Anglers no longer visited them, for all the fish had died.

In the gutters under the eaves and between the shingles of the roofs, a white granular powder still showed a few patches; some weeks before it had fallen like snow upon the roofs and the lawns, the fields and streams.

No witchcraft, no enemy action had silenced the rebirth of new life in this stricken world. The people had done it themselves.

This town does not actually exist, but it might easily have a thousand counterparts in America or elsewhere in the world. I know of no community that has experienced all the misfortunes I describe. Yet every one of these disasters has actually happened somewhere, and many real communities have already suffered a substantial number of them. A grim spectre has crept upon us almost unnoticed, and this imagined tragedy may easily become a stark reality we all shall know.

What has already silenced the voices of spring in countless towns in America? This book is an attempt to explain.

The Obligation to Endure

The history of life on earth has been a history of interaction between living things and their surroundings. To a large extent, the physical form and the habits of the Earth's vegetation and its animal life have been moulded by the environment. Considering the whole span of earthly time, the opposite effect, in which life actually modifies its surroundings, has been relatively slight. Only within the moment of time represented by the present century has one species – man – acquired significant power to alter the nature of his world.

During the past quarter century this power has not only increased to one of disturbing magnitude but it has changed in character. The most alarming of all man's assaults upon the environment is the contamination of air, earth, rivers, and sea with dangerous and even lethal materials. This pollution is for the most part irrecoverable; the chain of evil it initiates not only in the world that must support life but in living tissues is for the most part irreversible. In this now universal contamination of the environment, chemicals are the sinister and little-recognized partners of radiation in changing the very nature of the world – the very nature of its life. Strontium 90, released through nuclear explosions into the air, comes to earth in rain or drifts down as fallout, lodges in soil, enters into the grass or corn or wheat grown there, and in time takes up its abode in the bones of a human being, there to remain until his death. Similarly, chemicals sprayed on croplands or forests or gardens lie long in soil, entering into living organisms, passing from one to another in a chain of poisoning and death. Or they pass mysteriously by underground streams until they emerge and, through the alchemy of air and sunlight, combine into new forms that kill vegetation, sicken cattle, and work unknown harm on those who drink from once-pure wells. As Albert Schweitzer has said, 'Man can hardly even recognize the devils of his own creation.'

It took hundreds of millions of years to produce the life that now inhabits the earth – aeons of time in which that developing and evolving and diversifying life reached a state of adjustment and balance with its surroundings. The environment, rigorously shaping and directing the life it supported, contained elements that were hostile as well as supporting. Certain rocks gave out dangerous radiation; even within the light of the sun, from which all life draws its energy, there were short-wave radiations with power to injure. Given time – time not in years but in millennia – life adjusts, and a balance has been reached. For time is the essential ingredient; but in the modern world there is no time.

The rapidity of change and the speed with which new situations are created follow the impetuous and heedless pace of man rather than the deliberate pace of nature. Radiation is no longer merely the background radiation of rocks, the bombardment of cosmic rays, the ultraviolet of the sun that have existed before there was any life on earth; radiation is now the unnatural creation of man's tampering with the atom. The chemicals to which life is asked to make its adjustment are no longer merely the calcium and silica and copper and all the rest of the minerals washed out of the rocks and carried in rivers to the sea; they are the synthetic creations of man's inventive mind, brewed in his laboratories, and having no counterparts in nature.

To adjust to these chemicals would require time on the scale that is nature's; it would require not merely the years of a man's life but the life of generations. And even this, were it by some miracle possible, would be futile, for the new chemicals come from our laboratories in an endless stream; almost five hundred annually find their way into actual use in the US alone. The figure is staggering and its implications are not easily grasped – five hundred new chemicals to which the bodies of men and animals are required somehow to adapt each year, chemicals totally outside the limits of biologic experience.

Among them are many that are used in man's war against nature. Since the mid 1940s over two hundred basic chemicals have been created for use in killing insects, weeds, rodents and other organisms described in the modern vernacular as 'pests'; and they are sold under several thousand different brand names.

These sprays, dusts and aerosols are now applied almost universally to farms, gardens, forests, and homes – non-selective chemicals that have the power to kill every insect, the 'good' and the 'bad', to still the song of birds and the leaping of fish in the streams, to coat the leaves with a deadly film, and to linger on in soil – all this though the intended target may be only a few weeds or insects. Can anyone believe it is possible to lay down such a barrage of poisons on the surface of the earth without making it unfit for all life? They should not be called 'insecticides', but 'biocides'.

The whole process of spraying seems caught up in an endless spiral. Since DDT was released for civilian use, a process of escalation has been going on in which ever more toxic materials must be found. This has happened because insects, in a triumphant vindication of Darwin's principle of the survival of the fittest, have evolved super races immune to the particular insecticide used, hence a deadlier one has always to be developed – and then a deadlier one than that. It has happened also because, for reasons to be described later, destructive insects often undergo a 'flareback', or resurgence, after spraying, in numbers greater than before. Thus the chemical war is never won, and all life is caught in its violent crossfire.

Along with the possibility of the extinction of mankind by nuclear war, the central problem of our age has therefore become the contamination of man's total environment with such substances of incredible potential for harm – substances that accumulate in the tissues of plants and animals and even penetrate the germ cells to shatter or alter the very material of heredity upon which the shape of the future depends.

Some would-be architects of our future look towards a time when it will be possible to alter the human germplasm by design. But we may easily be doing so now by inadvertence, for many chemicals, like radiation, bring about gene mutations. It is ironic to think that man might determine his own future by something so seemingly trivial as the choice of an insect spray.

All this has been risked – for what? Future historians may well be amazed by our distorted sense of proportion. How could intelligent beings seek to control a few unwanted species by a method that contaminated the entire environment and brought the threat of disease and death even to their own kind? Yet this is precisely what we have done. We have done it, moreover, for reasons that collapse the moment we examine them. We are told that the enormous and expanding use of pesticides is necessary to maintain farm production. Yet is our real problem not one of *over-production*? Our farms, despite measures to remove acreages from production and to pay farmers *not* to produce, have yielded such a staggering excess of crops that the American taxpayer in 1962 is paying out more than one billion dollars a year as the total carrying cost of the surplus-food storage programme. And the situation is not helped when one branch of the Agriculture Department tries to reduce production while another states, as it did in 1958,

> It is believed generally that reduction of crop acreages under provisions of the Soil Bank will stimulate interest in use of chemicals to obtain maximum production on the land retained in crops.

All this is not to say there is no insect problem and no need of control. I am saying, rather, that control must be geared to realities, not to mythical situations, and that the methods employed must be such that they do not destroy us along with the insects.

The problem whose attempted solution has brought such a train of disaster in its wake is an accompaniment of our modern way of life. Long before the age of man, insects inhabited the earth – a group of extraordinarily varied and adaptable beings. Over the course of time since man's advent, a small percentage of the more than half a million species of insects have come into conflict with human welfare in two principal ways: as competitors for the food supply and as carriers of human disease.

Disease-carrying insects become important where human beings are crowded together, especially under conditions where sanitation is poor, as in time of natural disaster or war or in situations of extreme poverty and deprivation. Then control of some sort becomes necessary. It is a sobering fact, however, as we shall presently see, that the method of massive chemical control has had only limited success, and also threatens to worsen the very conditions it is intended to curb.

Under primitive agricultural conditions the farmer had few insect problems. These arose with the intensification of agriculture – the devotion of immense acreages to a single crop. Such a system set the stage for explosive increases in specific insect populations. Single-crop farming does not take advantage of the principles by which nature works; it is agriculture as an engineer might conceive it to be. Nature has introduced great variety into the landscape, but man has displayed a passion for simplifying it. Thus he undoes the built-in checks and balances by which nature holds the species within bounds. One important natural check is a limit on the amount of suitable habitat for each species. Obviously then, an insect that lives on wheat can build up its population to much higher levels on a farm devoted to wheat than on one in which wheat is intermingled with other crops to which the insect is not adapted.

The same thing happens in other situations. A generation or more ago, the towns of large areas of the US lined their streets with the noble elm tree. Now the beauty they hopefully created is threatened with complete destruction as disease sweeps through the elms, carried by a beetle that would have only a limited chance to build up large populations and to spread from tree to tree if the elms were only occasional trees in a richly diversified planting.

Another factor in the modern insect problem is one that must be viewed against a background of geologic and human history: the spreading of thousands of different kinds of organisms from their native homes to invade new territories. This worldwide migration has been studied and graphically described by the British ecologist Charles Elton in his recent book *The Ecology of Invasions by Animals and Plants* (1958). During the Cretaceous Period, some 100 million years ago, flooding seas cut many land bridges between continents and living things found themselves confined in what Elton calls 'colossal separate nature reserves'. There, isolated from others of their kind, they developed many new species. When some of the land masses were joined again, about 15 million years ago, these species began to move out into new territories – a movement that is not only still in progress but is now receiving considerable assistance from man.

The importation of plants is the primary agent in the modern spread of species, for animals have almost invariably gone along with the plants, quarantine being a comparatively recent and not completely effective innovation. The United States Office of Plant Introduction alone has introduced almost 200,000 species and varieties of plants from all over the world. Nearly half of the 180 or so major insect enemies of plants in the US are accidental imports from abroad, and most of them have come as hitch-hikers on plants.

In new territory, out of reach of the restraining hand of the natural enemies that kept down its numbers in its native land, an invading plant or animal is able to become enormously abundant. Thus it is no accident that our most troublesome insects are introduced species.

These invasions, both the naturally occurring and those dependent on human assistance, are likely to continue indefinitely. Quarantine and massive chemical campaigns are only extremely expensive ways of buying time. We are faced, according to Dr Elton, 'with a life-and-death need not just to find new technological means of suppressing this plant or that animal'; instead we need the basic knowledge of animal populations and their relations to their surroundings that will 'promote an even balance and damp down the explosive power of outbreaks and new invasions'.

Much of the necessary knowledge is now available but we do not use it. We train ecologists in our universities and even employ them in our governmental agencies but we seldom take their advice. We allow the chemical death rain to fall as though there were no alternatives whereas in fact there are many, and our ingenuity could soon discover many more if given opportunity. Have we fallen into a mesmerized state that makes us accept as inevitable that which is inferior or detrimental, as though having lost the will or the vision to demand that which is good? Such thinking, in the words of the ecologist Paul Shepard,

> idealizes life with only its head out of water, inches above the limits of toleration of the corruption of its own environment... Why should we tolerate a diet of weak poisons, a home in insipid surroundings, a circle of acquaintances who are not quite our enemies, the noise of motors with just enough relief to prevent insanity? Who would want to live in a world which is just not quite fatal?

Yet such a world is pressed upon us. The crusade to create a chemically sterile, insect-free world seems to have engendered a fanatic zeal on the part of many specialists and most of the so-called control agencies. On every hand there is evidence that those engaged in spraying operations exercise a ruthless power. 'The regulatory entomologists … function as prosecutor, judge and jury, tax assessor and collector and sheriff to enforce their own orders', said Connecticut entomologist Neely Turner. The most flagrant abuses go unchecked in both state and federal agencies.

It is not my contention that chemical insecticides must never be used. I do contend that we have put poisonous and biologically potent chemicals indiscriminately into the hands of persons largely or wholly ignorant of their potentials for harm. We have subjected enormous numbers of people to contact with these poisons, without their consent and often without their knowledge. If the Bill of Rights contains no guarantee that a citizen shall be secure against lethal poisons distributed either by private individuals or by public officials, it is surely only because our forefathers, despite their considerable wisdom and foresight, could conceive of no such problem.

I contend, furthermore, that we have allowed these chemicals to be used with little or no advance investigation of their effect on soil, water, wildlife and man himself. Future generations are unlikely to condone our lack of prudent concern for the integrity of the natural world that supports all life.

There is still very limited awareness of the nature of the threat. This is an era of specialists, each of whom sees his own problem and is unaware of or intolerant of the larger frame into which it fits. It is also an era dominated by industry, in which the right to make a dollar at whatever cost is seldom challenged. When the public protests, confronted with some obvious evidence of damaging results of pesticide applications, it is fed little tranquillizing pills of half truth. We urgently need an end to these false assurances, to the sugar coating of unpalatable facts. It is the public that is being asked to assume the risks that the insect controllers calculate. The public must decide whether it wishes to continue on the present road, and it can do so only when in full possession of the facts. In the words of Jean Rostand, 'The obligation to endure gives us the right to know.'

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2

Reality Cheques

Jules Pretty

The Real Costs of Food

When we buy or bake our daily bread, do we ever wonder about how much it really costs? We like it when our food is cheap, and complain when prices rise. Indeed, riots over food prices date back at least to Roman times. Governments have long since intervened to keep food cheap in the shops, and tell us that policies designed to do exactly this are succeeding. In most industrialized countries, the proportion of the average household budget spent on food has been declining in recent decades. Food is getting cheaper relative to other goods, and many believe that this must benefit everyone as we all need to eat food. But we have come to believe a damaging myth. Food is not cheap. It only appears cheap in the shop because we are not encouraged to think of the hidden costs of damage caused to the environment and human health by certain systems of agricultural production. Thus we actually pay three times for our food. Once at the till in the shop, a second time through taxes that are used to subsidize farmers or support agricultural development, and a third time to clean up the environmental and health side effects. Food looks cheap because we count these costs elsewhere in society. As economists put it, the real costs are not internalized in prices.[1]

This is not to say that prices in the shop should rise, as this would penalize the poor over the wealthy. Using taxes to raise money to support agricultural development is also potentially progressive, as the rich pay proportionally more in taxes, and the poor, who spend proportionally more of their budget on food, benefit if prices stay low. But this idea of fairness falters when set against the massive distortions brought about by modern agricultural systems that additionally impose large environmental and health costs throughout economies. Other people and institutions pay these costs, and this is both unfair and inefficient. If we were able to add up the real costs of producing food, we would find that modern industrialized systems of production perform poorly in comparison with sustainable systems. This is because we permit cost-shifting – the costs of ill health, lost biodiversity

Reprinted from Pretty J. 2002. Reality Cheques, in Pretty J. *Agri-culture*. Earthscan, London.

and water pollution are transferred away from farmers, and so not paid by those producing the food nor included in the price of the products sold. Until recently, though, we have lacked the methods to put a price on these side effects.

When we conceive of agriculture as more than simply a food factory, indeed as a multifunctional activity with many side effects, then this idea that farmers do only one thing must change. Of course, it was not always like this. It is modern agriculture that has brought a narrow view of farming, and it has led us to crisis. The rural environment in industrialized countries suffers, the food we eat is as likely to do as much harm as good, and we still think food is cheap. The following words were written more than 50 years ago, just before the advent of modern industrialized farming.

> Why is there so much controversy about Britain's agricultural policy, and why are farmers so disturbed about the future?... After the last war, the people of these islands were anxious to establish food production on a secure basis, yet, in spite of public good will, the farming industry has been through a period of insecurity and chaotic conditions.

These are the opening words to a national enquiry that could have been written about a contemporary crisis. Yet they are by Lord Astor, written in 1945 to introduce the Astor and Rowntree review of agriculture. This enquiry was critical of the replacement of mixed methods with standardized farming. They said, 'to farm properly you have got to maintain soil fertility; to maintain soil fertility you need a mixed farming system'. They believed that farming would only succeed if it maintained the health of the whole system, beginning in particular with the maintenance of soil fertility: 'obviously it is not only sound business practice but plain common sense to take steps to maintain the health and fertility of soil'.[2]

But in the enquiry, some witnesses disagreed, and called for a 'specialised and mechanised farming', though interestingly, the farming establishment at the time largely supported the idea of mixed farming. But in the end, the desire for public subsidies to encourage increases in food production took precedence, and these were more easily applied to simplified systems than mixed ones. The 1947 Agriculture Act was the outcome, a giant leap forward for modern, simplified agriculture, and a large step away from farming that valued nature's assets for farming. Sir George Stapledon, a British scientist knighted for his research on grasslands, was another perceptive scientist well ahead of his time. He too was against monocultures and in favour of diversity, arguing in 1941 that 'senseless systems of monoculture designed to produce food and other crops at the cheapest possible cost have rendered waste literally millions of acres of once fertile or potentially fertile country'.[3] In his final years, just a decade after the 1947 Act, he said:

> today technology has begun to run riot and amazingly enough perhaps nowhere more so than on the most productive farms... Man is putting all his money on narrow specialisation and on the newly dawned age of technology has backed a wild horse which given its head is bound to get out of control.

Wise words from eminent politicians and scientists. But lost on the altar of progress. Until now, perhaps, as new ideas on agriculture have begun to emerge and gather credence.

Agriculture's Unique Multifunctionality

We should all now be asking: what is farming for? Clearly, in the first instance, to produce food, and we have become very good at it. A great success, but only if our measures of efficiency are narrow. Agriculture is unique as an economic sector. It does more than just produce food, fibre, oil and timber. It has a profound impact on many aspects of local, national and global economies and ecosystems. These impacts can be either positive or negative. The negative ones are worrying. Pesticides and nutrients leaching from farms have to be removed from drinking water, and these costs are paid by water consumers, not by the polluters. The polluters, therefore, benefit by not paying to clean up the mess they have created, and have no incentive to change behaviour. What also makes agriculture unique is that it affects the very assets on which it relies for success. Agricultural systems at all levels rely for their success on the value of services flowing from the total stock of assets that they control, and five types of asset, natural, social, human, physical and financial capital, are now recognized as being important.[4]

Natural capital produces nature's goods and services, and comprises food, both farmed and harvested or caught from the wild, wood and fibre; water supply and regulation; treatment, assimilation and decomposition of wastes; nutrient cycling and fixation; soil formation; biological control of pests; climate regulation; wildlife habitats; storm protection and flood control; carbon sequestration; pollination; and recreation and leisure. *Social capital* yields a flow of mutually beneficial collective action, contributing to the cohesiveness of people in their societies. The social assets comprising social capital include norms, values and attitudes that predispose people to cooperate; relations of trust, reciprocity and obligations; and common rules and sanctions mutually agreed or handed-down. These are connected and structured in networks and groups.

Human capital is the total capability residing in individuals, based on their stock of knowledge skills, health and nutrition. It is enhanced by access to services that provide these, such as schools, medical services and adult training. People's productivity is increased by their capacity to interact with productive technologies and with other people. Leadership and organizational skills are particularly important in making other resources more valuable. *Physical capital* is the store of human-made material resources, and comprises buildings, such as housing and factories, market infrastructure, irrigation works, roads and bridges, tools and tractors, communications, and energy and transportation systems, that make labour more productive. *Financial capital* is more of an accounting concept, as it serves as a facilitating role rather than as a source of productivity in and of itself. It represents accumulated claims on goods and services, built up through financial systems that gather savings and issue credit, such as pensions, remittances, welfare payments, grants and subsidies.

As agricultural systems shape the very assets on which they rely for inputs, a vital feedback loop occurs from outcomes to inputs. Donald Worster's three principles for good farming capture this idea. It is farming that makes people healthier, farming that promotes a more just society, and farming that preserves the earth and its networks of life. He says 'the need for a new agriculture does not absolve us from the moral duty and common-sense advice to farm in an ecologically rational way. Good farming protects the land, even when it uses it.'[5] Thus sustainable agricultural systems tend to have a positive effect on natural, social and human capital, whilst unsustainable ones feed back to deplete these assets, leaving less for future generations. For example, an agricultural system that erodes soil whilst producing food externalizes costs that others must bear. But one that sequesters carbon in soils through organic matter accumulation helps to mediate climate change. Similarly, a diverse agricultural system that enhances on-farm wildlife for pest control contributes to wider stocks of biodiversity, whilst simplified modernized systems that eliminate wildlife do not. Agricultural systems that offer labour-absorption opportunities, through resource improvements or value-added activities, can boost economies and help to reverse rural-to-urban migration patterns.

Agriculture is, therefore, fundamentally multifunctional. It jointly produces many unique non-food functions that cannot be produced by other economic sectors so efficiently. Clearly, a key policy challenge, for both industrialized and developing countries, is to find ways to maintain and enhance food production. But the key question is: can this be done whilst seeking both to improve the positive side effects and to eliminate the negative ones? It will not be easy, as past agricultural development has tended to ignore both the multifunctionality of agriculture and the pervasive external costs.[6]

This leads us to a simple and clear definition for sustainable agriculture. It is farming that makes the best use of nature's goods and services whilst not damaging the environment.[7] It does this by integrating natural processes such as nutrient cycling, nitrogen fixation, soil regeneration and natural enemies of pests into food production processes. It also minimizes the use of non-renewable inputs that damage the environment or harm the health of farmers and consumers. It makes better use of the knowledge and skills of farmers, so improving their self-reliance, and it makes productive use of people's capacities to work together to solve common management problems. Through this, sustainable agriculture also contributes to a range of public goods, such as clean water, wildlife, carbon sequestration in soils, flood protection and landscape quality.

Putting Monetary Values on Externalities

Most economic activities affect the environment, either through the use of natural resources as an input or by using the 'clean' environment as a sink for pollution. The costs of using the environment in this way are called externalities. As they are side effects of the economic activity, they are external to markets, and so their costs are not part of the prices paid by producers or consumers. When such externalities are not included in prices, they distort the market by encouraging activities that are costly to society even if the private benefits are substantial. The types of externalities encountered in the agricultural sector have several features. Their costs are often neglected, and frequently occur with a time lag. They often damage groups whose interests are not represented, and the identity of the producer of the externality is not always known.[8]

In practice, there is little agreed data on the economic cost of agricultural externalities. This is partly because the costs are highly dispersed and affect many sectors of economies. It is also necessary to know about the value of nature's goods and services, and what happens when these largely unmarketed goods are lost. As the current system of economic accounting grossly underestimates the current and future value of natural capital, this makes the task even more difficult.[9] It is relatively easy, for example, to count the treatment costs following pollution, but much more difficult to value, for example, skylarks singing on a summer's day, and the costs incurred when they are lost.

Several studies have recently put a cost on the negative externalities of agriculture in China, Germany, The Netherlands, the Philippines, the UK and the US.[10] When it is possible to make the calculations, our understanding of what is the best or most efficient form of agriculture can change rapidly. In the Philippines, researchers from the International Rice Research Institute (IRRI) found that modern rice cultivation was costly to human health. They investigated the health status of rice farmers exposed to pesticides, and estimated the monetary costs of significantly increased incidence of eye, skin, lung and neurological disorders. By incorporating these into the economics of pest control, they found that modern, high-pesticide systems suffer twice, as with nine pesticide sprays per season they returned less per hectare than the integrated pest management strategies, and cost the most in terms of ill health. Any expected positive production benefits of applying pesticides were overwhelmed by the health costs. Rice production using natural control methods has multifunctionality in contributing positively both to human health as well as sustaining food production.[11]

At the University of Essex, we recently developed a new framework to study the negative externalities of UK agriculture. This uses seven cost categories to assess negative environmental and health costs – damage to water, air, soil and biodiversity, and damage to human health by pesticides, microorganisms and disease agents. The analysis of damage and monitoring costs counted only external costs, as private costs borne by farmers themselves, such as from increased pest or weed resistance from pesticide overuse, are not included. We conservatively estimated that the external costs of UK agriculture, almost all of which is modernized and industrialized, to be at least £1½–2 billion each year. Another study by Olivia Hartridge and David Pearce has also put the annual costs of modern agriculture in excess of £1 billion.[12] These are costs imposed on the rest of society, and effectively a hidden subsidy to the polluters.[13] The annual costs arise from damage to the atmosphere (£316 million), to water (£231 million), to biodiversity and landscapes (£126 million), to soils (£96 million) and to human health (£777 million).

Using a similar framework of analysis, the external costs in the US amount to nearly £13 billion per year.[14]

How do all these costs arise? Pesticides, nitrogen and phosphorus nutrients, soil, farm wastes and microorganisms escape from farms to pollute ground and surface water. Costs are incurred by water delivery companies, and then passed onto their customers, to remove these contaminants, to pay for restoring watercourses following pollution incidents and eutrophication, and to remove soil from water. Using UK water companies' returns for both capital and operating expenditure, we estimated annual external costs to be £125 million for the removal of pesticides below legal standards, £16 million for nitrate, £69 million for soil, and £23 million for *Cryptosporidium*.[15] These costs would be much greater if the policy goal were complete removal of all contamination.

Agriculture also contributes to atmospheric pollution through the emissions of four gases: methane from livestock, nitrous oxide from fertilizers, ammonia from livestock wastes and some fertilizers, and carbon dioxide from energy and fossil fuel consumption and loss of soil carbon. These in turn contribute to atmospheric warming (methane, nitrous oxide and carbon dioxide), ozone loss in the stratosphere (nitrous oxide), acidification of soils and water (ammonia) and eutrophication (ammonia). The annual cost for these gases is some £310 million.[16] A healthy soil is vital for agriculture, but modern farming has accelerated erosion, primarily through the cultivation of winter cereals, the conversion of pasture to arable, the removal of field boundaries and hedgerows, and overstocking of livestock on grasslands. Off-site costs arise when soil carried off farms by water or wind blocks ditches and roads, damages property, induces traffic accidents, increases the risk of floods, and pollutes water through sediments and associated nitrate, phosphate and pesticides. These amount to £14 million per year. Carbon in organic matter in soils is also rapidly lost when pastures are ploughed or when agricultural land is intensively cultivated, and adds another £82 million to the annual external costs.

Modern farming has had a severe impact on wildlife in the UK. More than nine-tenths of wildflower-rich meadows have been lost since the 1940s, together with a half of heathland, lowland fens, and valley and basin mires, and a third to a half of ancient lowland woods and hedgerows. Species diversity is also declining in the farmed habitat itself. Increase use of drainage and fertilizers has led to grass monocultures replacing flower-rich meadows, overgrazing of uplands has reduced species diversity, and herbicides have cut diversity in arable fields. Hedgerows were removed at a rate of 18,000 kilometres a year between the mid-1980s and 1990s. Farmland birds have particularly suffered, with the populations of nine species falling by more than a half in the 25 years to 1995.[17] The costs of restoring species and habitats under Biodiversity Action Plans were used as a proxy for the costs of wildlife and habitat losses, and together with the costs of replacing hedgerows, stonewalls and bee colonies, bring the annual costs to £126 million.

Pesticides can affect workers engaged in their manufacture, transport and disposal, operators who apply them in the field, and the general public. But there is still great uncertainty because of differing risks per product, poor understanding of chronic effects, such as in cancer causation, weak monitoring systems, and misdiagnoses by doctors.[18] For these reasons, it is very difficult to say exactly how many people are affected by pesticides each year. According to voluntary reporting to government, one to two hundred incidents occur each year in the UK.[19] However, a recent government survey of 2000 pesticide users found that 5 per cent reported at least one symptom in the past year and about which they had consulted a doctor, and a further 10 per cent had been affected, mostly by headaches, but had not consulted a doctor, incurring annual costs of about £1 million. Chronic health hazards associated with pesticides are even more difficult to assess. Pesticides are ingested via food and water, and these represent some risk to the public. With current scientific knowledge, it is impossible to state categorically whether or not certain pesticides play a role in cancer causation. Other serious health problems arising from agriculture are foodborne illnesses, antibiotic resistance and BSE-CJD.[20]

These external costs of UK agriculture are alarming. They should call into question what we mean by efficiency. Farming receives £3 billion of public subsidies each year, yet causes another £1½ billion of costs elsewhere in the economy. If we had no alternatives, then we would have to accept these costs. But, in every case, there are choices. Pesticides do not have to get into water. Indeed, they do not need to be used at all in many farm systems. The pesticide market in the UK is £500 million pounds, yet we pay £120million just to clean them out of drinking water. We do not need farming that damages biodiversity and landscapes; we do not need intensive livestock production that encourages infections and overuse of antibiotics. Not all costs, though, are subject to immediate elimination with sustainable methods of production. Cows will still belch methane, until animal feed scientists find a way of amending ruminant biochemistry to prevent its emission. But it is clear that many of these massive distortions could be removed with some clear thinking, firm policy action and brave action by farmers.[21]

The Side Effects of Intensive Food Production on Water and Wetlands

One problem with the redesign of landscape for modern agriculture is that important natural features and functions are lost. Watercourses and bodies are one of the most tamed and abused features. Wetlands have been drained, rivers straightened or hidden behind levees, aquifers mined, and rivers, lakes and seas polluted, mostly to ensure that productive farmland is protected from harm or excessive costs. Once again, though, the narrow view of the value of farmland for food production above all other uses has caused secondary problems. According to the National Research Council, 47 million hectares of wetlands in the US were drained in the past two centuries, and 85 per cent of inland waters are now artificially controlled. This created new farmland, to the benefit of farmers. But remove the wetlands, and the many valued services they provide are also lost. They are habitats for biodiversity, capture nutrients that run off fields, provide flood protection and are important cultural features of the landscape.

Donald Worster describes growing up within 30 metres of the already tamed Cow Creek in Kansas: 'we could not see it from our windows; we could only see the levee'. In the 19th century, as the town had expanded by the river, and the early settlers converted land to wheat cultivation, so the normal and regular flooding of the river started to cause considerable economic damage. Episodes of flooding and continued expenditure on flood protection continued for decades, until a major flood in 1941 finally led the Army Corps of Engineers to construct a series of 4-metre-high levees: 'now at long last the good Kansas folk, having vanquished the Indians and the bison and the sandhill cranes and the antelope, had managed to vanquish Cow Creek. Abruptly, it disappeared from their lives.' This is the alarming part. When valued landscape features have gone, or have been replaced, the everyday experiences of local people will steadily erode old memories. The young will not know, while the old will be troubled, until they pass on too.[22] Meanwhile, we all lose.

In Europe, river valleys used to contain many water meadows, fields likely to be flooded by overflowing rivers, and so used productively to produce a late winter or early spring crop of grass. More importantly, when the river did flood, water was stored on the meadows, and did not harm housing or other vulnerable areas. But in the drive towards intensification of food production, most of these meadows have been converted to arable fields. At the same time, rivers have been tamed through channelling, field sizes increased, hedgerows removed, and houses built on vulnerable land. Now, when it rains, the consequence is increased flooding to vulnerable areas. It looks as though there has been 'too much' rain, but in truth it is largely due to changes in the landscape.

In Germany, Rienk van der Ploeg and colleagues have correlated loss of meadows with an increased incidence of inland floods, with 6 of the 12 most extreme events over a century having occurred since 1983. They show that changes in the diversity of use of agricultural land are the main cause. In particular, permanent meadows have been converted to arable fields, some 1½ million hectares since the mid-1960s, which because of surface sealing and compaction are less likely to hold water during winter. Another 4½ million hectares of wetland soils have been drained since the 1940s. Thus when it rains, water contributes more rapidly to river water discharge, so increasing the likelihood of flooding. The cost of two floods in 1993 and 1995 were nearly DM2 billion, and van der Ploeg concludes that the conversion of arable back to permanent meadows would be economically and environmentally beneficial: 'it must be acknowledged that any further increase in agricultural productivity is likely to cause additional adverse environmental effects. Future farm policy must pay more attention to the environment'.[23]

Japan provides another example of the wider value of agricultural wetlands, in this case irrigated paddy rice fields. Japan's very high rainfall is concentrated into a few months on a landscape characterized by a high mountain chain. With a very short flow time to the sea, this means that much of the country is subject to severe flood risk. Paddy rice farming, though, provides an important sink for this water.

There are more than 2 million hectares of paddy rice in Japan, and each of these hectares holds about 1000 tonnes of water each year. In the Koshigaya City basin, 25 kilometres north of Tokyo, paddy fields close to the city have been steadily converted to residential uses over the past quarter century. But as the area of paddy has declined by about 1000 hectares since the mid-1970s, so the incidence of flooding has increased. Each year, 1000–3000 houses are flooded. In whole watersheds, woods and farms on steep slopes have been identified as having the greatest value in buffering and slowing water flow, and minimizing landslides. Diversity, though, is critical. As Yoshitake Kato and colleagues have put it:

> traditional villages in rural areas include settlements, paddy fields, crop fields and forested hills or mountains, all as linked landscape. The systems were dependent on all their parts. The decline of farming in the uplands, together with loss of forests, threatens the stability of whole watersheds.[24]

In China, the 500,000 hectares of wetlands that have been reclaimed for crop production in the past 50 years have meant the loss of flood-water storage capacity of some 50 billion cubic metres, a major reason for the $20 billion flood damage caused in 1998.[25] In many agricultural systems, over-intensive use of the land has resulted in sharp declines in soil organic matter and/or increases in soil erosion, some of which in turn threatens the viability of agriculture itself. In South Asia, for example, a quarter of farmland is affected by water erosion, a fifth by wind erosion, and a sixth by salinization and waterlogging.[26]

Putting a value on wetlands and watercourses, so that we can calculate how much is lost when they are damaged or destroyed, is not a trivial task. Economists have no agreed value for wetlands, though various studies indicate that individual bodies can provide several million dollars of free services to nearby communities for waste assimilation and treatment. A recent US Department of Agriculture study put wetland monetary value at $300,000 per hectare per year. Another way to assess value is to investigate how much people pay to visit wetlands, whether to watch or photograph biodiversity, or indeed to shoot it. In the US, it is estimated that 50 million people each year spend $10 billion observing and photographing wetland flora and fauna, 31 million anglers spend $16 billion on fishing, and 3 million waterfowl hunters spend nearly $700 million annually on shooting it. A recent meta-analysis of economic studies of people's willingness-to-pay for recreational services of wetlands and watercourses puts the average value in Europe to be £20–25 per person per hectare per year.[27] Thus each hectare of wetland converted to another purpose means the loss of at least £20 of value to the public. There are, of course, limitations in these exercises, as monetary values cannot be allocated to all uses.

One of the most serious side effects of agriculture is the leaching and run-off of nutrients, and their disruption of water ecosystems. Eutrophication is the term used to describe nutrient enrichment of water that leads to excessive algal growth, disruption of whole food webs, and in the worst cases complete eradication of all life through deoxygenation. The most notorious example is the Gulf of Mexico dead-zone, an area of 5000–18,000km^2 of sea that has received so much nutrient input that all aquatic life has been killed. The cost of farm overuse of nutrients in the Mississippi basin is thus borne by the fishing families of Louisiana. No one has yet put a cost on these losses, yet if they were internalized in the prices of fertilizers, or the activities of intensive livestock units, we would expect to see much greater care shown about such polluting activities.[28]

At the University of Essex, we recently conducted a study of the costs of nutrient enrichment of water in the UK.[29] Eutrophication affects the value of waterside properties, and reduces the recreational and amenity value of water bodies for water sports, angling and general amenity, for industrial uses, for the tourist industry and for commercial aquaculture, fisheries and shell-fisheries. Additional costs are incurred through a variety of social responses by both statutory and non-statutory agencies. In total, we estimate nutrient enrichment to cost some £150 million per year in the UK.[30]

Industrialized Agriculture and Foodborne Illnesses

Having mostly conquered hunger in industrialized countries, it is a sad irony that food is now a major source of ill health. We eat too much, we eat the wrong mix of foods, and we get ill from foodborne illnesses. In Europe, 10–20 per cent of all people are defined as obese, with a body mass index greater than 30kg per square metre. The World Health Organization estimates that 2–7 per cent of health care costs in Europe arise from obesity, and one American study suggests that a 10 per cent weight loss amongst obese people would increase life expectancy by 2–7 months, and produce lifetime benefits of US$2000–6000 per person.[31] Several diseases are strongly linked to unbalanced food consumption, including non-insulin dependent diabetes, the incidence of which is growing rapidly, together with strokes, coronary heart disease and some cancers.

Many of these health problems, though, are attributable to the choices consumers make. We could eat five portions of fruit and vegetable per day, thus protecting against many of these problems, but for a variety of reasons we do not. But we cannot choose when it comes to foodborne diseases. The WHO estimates that 130 million people in Europe are affected by foodborne diseases each year, mainly from biological sources, particularly strains of *Salmonella*, *Campylobacter*, *Listeria* and *E. coli*. *Salmonella* is the most common pathogen, accounting for up to 90 per cent of cases in some countries. Throughout the world, diarrhoea is the most common symptom of foodborne illness, and is a major cause of death and retardation of growth in infants. There is evidence that cases of *Campylobacter* and *Salmonella* poisoning are increasing in Europe, though some of the increases can be explained by better monitoring systems.[32] In the US, the incidence of foodborne illness is greater, perhaps because of the greater industrialization of agriculture and, in particular, of livestock raising. According to the government's Centers for Disease

Control, 76 million people in the US fall ill each year from foodborne illness, of whom more than 300,000 are hospitalized and 5000 die.[33]

The costs of foodborne illnesses are massive. For the US, the Institute for Medicine at the National Academy of Sciences, the US Department of Agriculture (USDA) and the World Health Organization estimates them to be between $34 and $110 billion dollars per year. In the UK, the government's Food Standards Agency estimates that each of the annual 5 million cases of food poisoning costs on average £85 for costs to health services and losses to businesses, putting the annual cost at more than £400 million. These data suggest that one in four Americans and one on ten Britons suffer from food poisoning each year.[34]

Some of these foodborne illnesses arise from shellfish, others are associated with mass catering or occur in the food processing chain. But it is the initial sources of infection on the farm, combined with the overuse of antibiotics for growth promotion, that is an increasing source of disquiet. The concentration of livestock into factory feedlots, broiler sheds and colossal pig units promotes infection and spread. As the WHO puts it 'the greatest risk appears to be the production of animal foods. It is from this source that the most serious health threats originate, for instance, Salmonella, Campylobacter, E.coli and Yersinia.' The pool of infection at the start of the food chain is now very serious. The USDA has found very high levels of microbial infections in US farm animals, particularly in broiler chickens and turkeys. *Clostridium* has been found in 30–40 per cent of flocks, *Campylobacter* in nearly 90 per cent, *Salmonella* in 20–30 per cent, and *Staphylococcus* in 65 per cent. These levels of infection are matched in some European countries, with more than 90 per cent of pig herds and nearly 50 per cent of cattle in The Netherlands and Denmark contaminated with *Campylobacter*. At these levels of incidence in animals, it is hardly surprising that illness incidence from meat consumption is so high. Incidence in pigs and cattle is much lower, but still a worrying 3–30 per cent of herds for these four pathogens (Table 2.1).

This extraordinary problem, slipping quietly behind a desire for ever-cheaper foods, is worsened by antibiotic resistance brought on by overuse of antibiotics for livestock growth promotion and over-prescription in medicine. Twenty-three thousand tonnes of antibiotics are used in the US each year, of which 11 thousand are given to animals, four-fifths of which is just for growth promotion. In the UK, 1200 tonnes of antibiotics are used each year, 40 per cent of which is for humans,

Table 2.1 *Incidence of microbial infection in farm animals, US*

	Proportion of individuals with infectious bacteria (%)			
	Broiler chickens	*Turkeys*	*Pigs*	*Cattle*
Clostridium	43	29	10	8
Campylobacter	88	90	32	1
Salmonella	29	19	8	3
Staphylococcus	65	65	16	8

30 per cent for farm animals, and 30 per cent for domestic pets and horses. Only one-fifth of the antibiotics and other antimicrobials used in modern agriculture are for therapeutic treatment of clinical diseases, with four-fifths for prophylactic use and growth promotion. The Centers for Disease Control say, 'antimicrobial resistance is a serious clinical and public health problem in the US', and one estimate from the Institute of Medicine suggests that such resistance costs $30 million per year. A UK House of Lords select committee enquiry was even more alarmed, recently stating, 'there is a continuing threat to human health from the imprudent use of antibiotics in animals … we may face the dire prospect of revisiting the pre-antibiotic era'.[35]

In both Europe and North America, the most common forms of antimicrobial resistance are to strains of antibiotics used in treating animals, and these are transferred to human patients. Some antibiotics, such as fluoroquinones and avoparcin, used to treat infections in poultry and as growth promoters, are now associated with dramatic increases in resistant diseases in humans. Fluoroquinone resistance is thought to be the main factor why *Campylobacter* infections have become so common in The Netherlands. As the WHO puts it, '*Campylobacter* species are now the commonest cause of bacterial gasteroenteritis is developed countries, and cases are predominantly associated with consumption of poultry'.[36] There is no such thing as a cheap chicken.

Putting a Monetary Value on Agricultural Landscapes

Landscapes are culturally valuable, and the aesthetic value we gain from them owes much to their emergence from agricultural practices. They are, of course, almost impossible to value in monetary terms. However, many proxies can be used, including how much governments are willing to pay farmers to produce certain habitats or landscapes, how often the public visits the countryside, and how much they spend when they get there. In the UK, several studies of agri-environmental policies have sought to put a value on positive environmental and landscape outcomes.[37] These schemes have attempted to restore some of the habitat and other positive countryside attributes that were lost during intensification as well as protect those attributes not yet lost.

UK agri-environmental schemes have been designed to deliver benefits in several forms, including biodiversity, landscape patterns, water quality, archaeological sites and enhanced access. Benefits may accrue to those in the immediate area of a scheme, to visitors from outside the area and to the public at large. The annual per-household benefits, using a variety of valuation methods such as contingent valuation, choice experiments and contingent ranking, vary from £2 to £30 pounds for most Environmentally Sensitive Areas, rising to £140 for the Norfolk Broads and £380 for Scottish machair grasslands. If we take the range of annual benefits per household to be £10–30, and assume that this is representative of the average households' preferences for all landscapes produced by agriculture, then this suggests national benefits of the order of £200–600 million. Expressed on a per hectare basis, this suggests annual benefits of £20–60 per hectare of arable and pasture land in the UK.

On the one hand, these are likely to be overestimates, assuming agri-environment schemes have already targeted certain landscapes because of their higher value. On the other hand, they could be substantial underestimates, as they omit to value such benefits as pathogen-free foods, uneroded soils, emission-free agriculture and biodiversity-producing systems, as well as focusing on the outcomes of a scheme rather than the whole landscape. There are too few studies yet to corroborate these data. One study in the UK compared paired organic and non-organic farms, and concluded that organic agriculture produces £75–125 per hectare of positive externalities each year, with particular benefits for soil health and wildlife.[38] As there are 3 million hectares of organic farming in Europe, the annual positive externalities could be £300 million, assuming benefits hold for the many organic farming systems across Europe.

Actual visits made to the countryside are another proxy measure of how much we value landscapes. Each year in the UK, day and overnight visitors make some 433 million visit-days to the countryside and another 118 million to the seaside.[39] The average spend per day or night varies from nearly £17 for UK day visitors, to £33 for UK overnight visitors, and just over £58 for overseas overnight visitors. This indicates that the 551 million visit-days to the countryside and seaside result in spending of £14 billion per year. This is three and a half times greater than the annual public subsidy of farming, and indicates just how much we value the landscape.

If it is clean water that is required, the value of an agricultural landscape can be substantial, as New York State has found out with its support for sustainable agriculture in the 500,000 hectare Catskill-Delaware watershed complex.[40] New York City gets 90 per cent of its drinking water from these watersheds, some 6 billion litres a day. In the late 1980s, though, the city was faced with having to construct a filtration facility to meet new drinking water standards, the cost of which would be $5–8 billion, plus another $200–500 million in annual operating costs. A third of the cropland in the watershed would have to be taken out of farming so as to reduce run-off of eroded soil, pesticides, nutrients and bacterial and protozoan pathogens.

Instead, the city opted for a collaborative approach with farmers. It supported the establishment of a Watershed Agricultural Council in the early 1990s, a partnership of farmers, government and private organizations with the dual aim of protecting the city's drinking water supply and sustaining the rural economy. It works on whole farm planning with each farm, tailoring solutions to local conditions to maximize reductions in off-site costs. The first two phases of the programme leading to the 85 per cent target in pollution reduction cost some $100 million, a small proportion of the cost of the filtration plant and its annual costs. Not only do taxpayers benefit from this approach to joint agri-environmental management, but so do farmers, the environment and rural economies.[41] The only surprising thing is that these initiatives are still rare.

Agriculture's Carbon Dividend

The greatest environmental problem we face anywhere in the world is now climate change, provoked by rising levels of anthropogenic greenhouse gases. It threatens to disrupt economies and ecosystems, challenge existing land uses, substantially raise sea levels, and drown coastal lands and even some whole countries. To slow down and eventually to reverse these changes, we need to reduce human-induced emissions of these gases, as well as find ways to capture or lock up carbon from the atmosphere. Sustainable agriculture can make an important contribution to climate change mitigation through both emissions reduction and carbon sequestration, and as the international markets for carbon expand, so sequestered carbon could represent an important new income source for farmers.[42]

Agricultural systems contribute to carbon emissions through the direct use of fossil fuels in farm operations, the indirect use of embodied energy in inputs that are energy-intensive to manufacture and transport, particularly fertilizers and pesticides, and the cultivation of soils resulting in the loss of soil organic matter. Agriculture is also an accumulator of carbon, offsetting losses when organic matter is accumulated in the soil, or when above-ground woody biomass acts either as a permanent sink or is used as an energy source that substitutes for fossil fuels.

Long-term agricultural experiments in both Europe and North America indicate that soil organic matter and soil carbon are lost during intensive cultivation. But both can be increased with sustainable management practices. The greatest dividend comes from conversion of arable to agroforestry as there is a benefit from both increased soil organic matter and the accumulation of above-ground woody biomass. Grasslands within rotations, zero-tillage farming, use of legumes and green manures, and high amendments of straw and manures, also lead to substantial carbon sequestration. There is now good evidence to show that sustainable agricultural systems can lead to the annual accumulation of 300–600kg of carbon per hectare, rising to several tonnes per hectare when trees are intercropped in cropping and grazing systems.

Agriculture as an economic sector also contributes to carbon emissions through the consumption of direct and indirect fossil fuel. With the increased use of nitrogen fertilizers, pumped irrigation and mechanical power, accounting for more than 90 per cent of the total energy inputs to farming, industrialized agriculture has become progressively less energy efficient. The difference between sustainable and conventional systems of production is striking. Low-input or organic rice in Bangladesh, China and Latin America is some 15–25 times more energy efficient than irrigated rice grown in the US. For each tonne of cereal or vegetable from industrialized high-input systems in Europe, 3000–10,000MJ of energy are consumed in its production. But for each tonne of cereal or vegetable from sustainable farming, only 500–1000MJ are consumed.[43]

It is now known that intensive cultivation of cereals leads to reductions in soil organic matter and carbon. But recent years have seen an extraordinary growth in the adoption of 'conservation tillage' and 'zero-tillage' systems, particularly in the

Americas. These systems of cultivation maintain a permanent or semi-permanent organic cover on the soil. The function is to protect the soil physically from the action of sun, rain and wind, and to feed soil biota. The result is reduced soil erosion and improved soil organic matter and carbon content. Zero-tillage systems and those using legumes as green manures and/or cover crops contribute to organic matter and carbon accumulation in the soil. Zero-till systems also have an additional benefit of requiring less fossil fuel for machinery passes. Intensive arable with zero-tillage results in the annual accumulation of 300–600kg of carbon per hectare, but with mixed rotations and cover crops can accumulate up to 1300kg of carbon per hectare.

The 1997 Kyoto Protocol to the UN Framework Convention on Climate Change established an international policy context for the reduction of carbon emissions and expansion in carbon sinks in order to address climate change. Under the protocol and the 2001 Bonn and Marakesh agreement, the principle of financial and technological transfers to land management projects and initiatives was established. Article 17 permits countries to produce certified emissions reductions, also known as offsets, and emissions reductions units through joint implementation projects. As it is cheaper at the margin for many countries to abate greenhouse gas emissions, such working together for joint implementation is in theory a cost-effective mechanism for achieving global targets.

But for real impacts on climate change to occur, sinks must become permanent. If lands under conservation tillage are ploughed, then all the gains in soil carbon and organic matter are lost. This poses a big challenge for trading systems, as there is no such thing as a permanent emissions reduction nor a permanently sequestered tonne of carbon. Despite these uncertainties, carbon banks, 'boards of trade' and trading systems first emerged during the year 2000. The early carbon trading systems set per tonne credit values mostly in the US$2–10 range, though the real value of each tonne sequestered is much higher. The important policy questions centre on how to establish permanent or indefinite sinks, how to prevent leakage, such as reploughing of zero-tilled fields or deforestation, how to agree measurements, and whether the cost of implementation can be justified through their additional side effects or multifunctionality.

We do not yet know how much carbon could be locked up in response to monetary incentives for carbon sequestration. The empirical evidence is relatively sparse, and practical experience even more limited. No agreed system of payment levels has yet been established. Another unresolved issue relates to the location for the greatest carbon returns on investments. Investments in creating sustainable systems in the tropics are likely to be cheaper than in temperate regions, where industrialized agriculture prevails. Such financial transfers from industrialized to developing countries could produce substantial net global benefits as well as benefit poor farmers. At current prices, it is clear that farmers will not become solely carbon farmers. However, systems accumulating carbon are also delivering many other public goods, such as improved biodiversity and clean water from watersheds, and policy makers may also seek to price these so as to increase the total payment package. Carbon, therefore, represents an important new source of income for farmers, as well as helping to encourage them to adopt sustainable practices.

Could Better Policies Help?

These external costs and benefits of agriculture raise important policy questions. In particular, should farmers receive public support for the public benefits they produce in addition to food? Should those that pollute have to pay for restoring the environment and human health? These two principles are called 'the provider gets' and 'the polluter pays', and they are important to both industrialized and developing countries. Three categories of policy instruments are available: advisory and institutional measures, regulatory and legal measures, and economic instruments. In practice, effective pollution control and supply of desired public goods requires a mix of all three approaches, together with integration across sectors.

Advisory and institutional measures have long formed the backbone of policies to internalize costs and so prevent agricultural pollution. These rely on the voluntary actions of farmers, and are favoured by policy makers because they are cheap and adaptable. Advice is commonly given in the form of codes of good agricultural practice, such as recommended rates of application of pesticides and fertilizer, or measures for soil erosion control. Most governments still employ extension agents to work with farmers on technology development and transfer. A variety of institutional mechanisms can also help to increase social capital and the uptake of more sustainable practices, including encouraging farmers to work together in study groups, investing in extension and advisory services to encourage greater interaction between farmers and extensionists, and encouraging new partnerships between farmers and other rural stakeholders, as regular exchanges and reciprocity increase trust and confidence, and lubricate cooperation.

Regulatory and legal measures are also used to internalize external costs. This can be done either by setting emissions standards for the discharge of a pollutant, or by establishing quality standards for the environment receiving the pollutant. Polluters who exceed standards are then subject to penalties. There are many types of standards, such as operating standards to protect workers, production standards to limit levels of contaminants of residues in foods, emissions standards to limit releases or discharges, such as of silage effluents, and environmental quality standards for undesirable pollutants in vulnerable environments, such as pesticides in water. But the problem with such regulations is that most agricultural pollutants are diffuse, or nonpoint, in nature. It is impossible for inspectors to ensure compliance on hundreds of thousands of farms in the way that they can with a small number of factories. Regulations are also used to eliminate certain practices, and include bans on spraying of pesticides close to rivers and on straw-burning in the UK, and the mandatory requirement to complete full nutrient accounts for farms, such as in The Netherlands and Switzerland. A final use for regulations is the designation and legal protection of certain habitats and species, which are set at national or international levels.

Economic instruments can be used either to ensure that the polluter bears the costs of the pollution damage and the abatement costs incurred in controlling the pollution. They can also be used to reward good behaviour. A variety of economic instruments are available for achieving internalization, including environmental taxes and charges, tradable permits and targeted use of public subsidies and incentives. Environmental taxes seek to shift the burden of taxation away from economic 'goods', such as labour, towards environmental 'bads', such as waste and pollution. Clearly the market prices for agricultural inputs do not currently reflect the full costs of their use. Environmental taxes or pollution payments, however, seek to internalize some of these costs, so encouraging individuals and businesses to use them more efficiently. Such taxes offer the opportunity of a 'double dividend' by cutting environmental damage, particularly from nonpoint sources of pollution, whilst promoting welfare. However, many opponents still believe that environmental taxes stifle economic growth, despite compelling evidence to the contrary.[44]

There are now a wide range of environmental taxes used by countries in Europe and North America. These include carbon and energy taxes in Belgium, Denmark and Sweden; chlorofluorocarbon taxes in Denmark and the US; sulphur taxes in Denmark, France, Finland and Sweden; nitrogen oxide charges in France and Sweden; leaded and unleaded petrol differentials in all European Union (EU) countries; landfill taxes in Denmark, The Netherlands and the UK; groundwater extraction charges in The Netherlands; and sewage charges in Spain and Sweden. However, environmental taxes have rarely been applied to agriculture, with the notable exception of pesticide taxes in Denmark, Finland, Sweden and in several states of the US; fertilizer taxes in Austria, Finland, Sweden, and again several states of the US; and manure charges in Belgium and The Netherlands.[45]

The alternative to penalizing farmers through taxation is to encourage them to adopt non-polluting technologies and practices. This can be done by offering direct subsidies for adoption of sustainable technologies, and by removing perverse subsidies that currently encourage polluting activities.[46] An important policy principle suggests that it is more efficient to promote practices that do not damage the environment rather than spending on cleaning up after a problem has been created. Many governments provide some direct or indirect public support to their domestic agricultural and rural sectors. Increasingly, payments are being shifted away from being production-linked, such as through price support or direct payments, to being retargeted to support sustainable practices. Generally, though, only small amounts of total budgets have been put aside for environmental improvements though such policies as the US Conservation Reserve Programme, the EU's agri-environmental and rural development programmes, and the Australian Landcare programme. Many now believe that all public support for farming should be entirely linked to the provision of public environmental and social goods.

The Radical Challenge of Integration

The substantial external costs of modern agriculture, and the known external benefits of sustainable agricultural systems, pose great challenges for policy makers. A range of policy reforms could do much to internalize some of these costs and benefits in prices. In practice, as no single solution is likely to suffice, the key issue rests on how policy makers choose an appropriate mix of solutions, how these are integrated, and how farmers, consumers and other stakeholders are involved in the process of reform itself. Attention will therefore need to be paid to the social and institutional processes that both encourage farmers to work and learn together, and result in integrated cross-sectoral partnerships. Policy integration is vital, yet most policies seeking to link agriculture with more environmentally-sensitive management are still highly fragmented.

The problem is that environmental policies have tended only to green the edges of farming. An essentially modernist agriculture remains much as it ever was, but is now tinged green. Non-crop habitats have been improved, perhaps some hedges, woodlands and wetlands. But the food is largely produced in the conventional manner. The bigger challenge is to find ways of substantially greening the middle of farming – in the field rather than around the edges. A thriving and sustainable agricultural sector requires both integrated action by farmers and communities, and integrated action by policy makers and planners. This implies both horizontal integration with better linkages between sectors, and vertical integration with better linkages from the micro- to macro-level. Most policy initiatives are still piecemeal, affecting only a small part of a individual farmer's practices, and so not necessarily leading to substantial shifts towards sustainability.

The 1990s saw considerable global progress towards the recognition of the need for policies to support sustainable agriculture. In a few countries, this has been translated into supportive and integrated policy frameworks. In most, however, sustainability policies remain at the margins. Only two countries – Cuba and Switzerland, discussed in more detail below – have given explicit national support for sustainable agriculture, putting it at the centre of agricultural development policy. Several countries have given sub-regional support, such as the states of Santa Caterina, Paraná and Rio Grande do Sol in southern Brazil supporting zero-tillage and catchment management, and some states in India supporting watershed management or participatory irrigation management. A much larger number have reformed parts of agricultural policies, such as China's support for integrated ecological demonstration villages, Kenya's catchment approach to soil conservation, Indonesia's ban on pesticides and programme for farmer field schools, India's support for soybean processing and marketing, Bolivia's regional integration of agricultural and rural policies, Sweden's support for organic agriculture, Burkina Faso's land policy, and Sri Lanka and the Philippines' stipulation that water users' groups manage irrigation systems.

One of the best examples of a carefully designed and integrated programme comes from China. In March 1994, the government published a White Paper to set out its plan for implementation of Agenda 21. This put forward ecological farming, known as *Shengtai Nongye* or agroecological engineering, as the approach to achieve sustainability in agriculture. Pilot projects have been established in some 2000 townships and villages spread across 150 counties. Policy for these 'eco-counties' is organized through a cross-ministry partnership, which uses a variety of incentives to encourage adoption of diverse production systems to replace monocultures. These include subsidies and loans, technical assistance, tax exemptions and deductions, security of land tenure, marketing services and linkages to research organizations. These eco-counties contain some 12 million hectares of land, about half of which is cropland, and though only covering a relatively small part of China's total agricultural land, do illustrate what is possible when policy is coordinated and holistic.

An even larger set of countries has seen some progress on agricultural sustainability at project and programme level. However, progress occurs despite, rather than because of, explicit policy support. No agriculture minister is likely to say they are against sustainable agriculture, yet good words remain to be translated into comprehensive policy reforms. Sustainable agricultural systems can be economically, environmentally and socially viable, and at the same time contribute positively to local livelihoods. But without appropriate policy support, they are likely to remain at best localized in extent, and at worst simply wither away. In Europe and North America, most policy analysts and sustainable agriculture organizations now agree that a policy framework that integrates support for farming together with rural development and the environment could create new jobs, protect and improve natural resources, and support rural communities. Such a policy could have many of the elements of the progressive Swiss and Cuban policy reforms made during the 1990s.

Cuba's National Policy for Sustainable Agriculture

At the turn of the century, Cuba was the only developing country with an explicit national policy for sustainable agriculture. To the end of the 1980s, Cuba's agricultural sector was heavily subsidized by the Soviet bloc. It imported more than half of all calories consumed, and 80–95 per cent of wheat, beans, fertilizer, pesticides and animal feed. It received three times the world price for its sugar. At the time, Cuba had the most scientists per head of population in Latin America, the most tractors per hectare, the second highest grain yields, the lowest infant mortality, the highest number of doctors per head population and the highest secondary school enrolment. But in 1990, trade with the Soviet bloc collapsed, leading to severe shortages in all imports, and restricting farmers' access to petroleum, fertilizers and pesticides.

The government's response was to declare an 'Alternative Model' as the official policy – an agriculture that focuses on technologies that substitute local knowledge, skills and resources for the imported inputs. It also emphasizes the diversification of agriculture, oxen to replace tractors, Integrated Pest Management to replace pesticides, and the promotion of better cooperation among farmers both within and between communities. It has taken time to succeed. Calorific availability was 2600 kilocalories per day in 1990, fell disastrously to between 1000–1500 kilocalories per day soon after the transition, leading to severe hunger, but subsequently rose to 2700 kilocalories per day by the end of the 1990s.

Two important strands to sustainable agriculture in Cuba have emerged. First intensive organic gardens have been developed in urban areas – self-provisioning gardens in schools and workplaces (*autoconsumos*), raised container-bed gardens (*organoponicos*) and intensive community gardens (*huertos intensivos*). There are now more than 7000 urban gardens, and productivity has grown from 1½kg per square metre to nearly 20kg per square metre. Second, sustainable agriculture is encouraged in rural areas, where the impact of the new policy has already been remarkable. More than 200 village-based and artisanal Centres for the Reproduction of Entomophages and Entomopathogens have been set up for biopesticide manufacture. Each year, they produce 1300 tonnes of *B.t.* sprays for lepidoptera control, nearly 800 tonnes of *Beaveria* sprays for beetle control, 200 tonnes of *Verticillium* for whitefly control and 2800 tonnes of *Trichoderma*, a natural enemy. Many biological control methods are proving more efficient than pesticides. Cut banana stems baited with honey to attract ants are placed in sweet potato fields, and have led to control of the sweet potato weevil. There are 170 vermicompost centres, the annual production of which has grown from 3 to 93 thousand tonnes. Crop rotations, green manuring, intercropping and soil conservation have all been incorporated into polyculture farming.

At the forefront of the transition towards sustainable agriculture has been the Grupo de Agricultura Organica, formerly known as the Asociación Cubanes Agricultural Organica, formed in 1993. GAO brings together farmers, field managers, field experts, researchers and government officials to help spread the idea that organic-based alternatives can produce sufficient food for Cubans. Despite great progress, there remain many difficulties, including proving the success of the alternative system to sceptical farmers, scientists and policy makers, developing new technologies sufficiently quickly to meet emergent problems, coordinating the many actors to work together, the need for continued decentralization of decision making to farmer level, and the appropriate land reform to encourage investment in natural asset-building.[47]

The Swiss National Policy for Sustainable Agriculture

The Swiss Federal Agricultural Law was revised in 1992 to target subsidies towards ecological practices, and then radically amended in 1996 following a national referendum in which 78 per cent of the public voted in favour of change.[48] The main priority was maintaining important positive side effects of upland livestock farming – in particular open meadows for skiing pistes in winter, but also maintenance of rural mountain communities that are at the root of Swiss culture. Policy now differentiates between three different levels of public support. Tier one provides support for specific biotypes, such as extensive grassland and meadows, high-stem fruit trees and hedges. Tier two supports integrated production with reduced inputs, meeting higher ecological standards than conventional farming, and Tier three provides the most support for organic farming. As the directors of the federal agricultural and environmental offices, Hans Berger and Philippe Roch, have said, 'in ecological terms, Swiss agriculture is on the road to sustainability. There are encouraging signs that the agricultural reform has already began to have positive effects on nature and the environment.'

Farmers must meet several minimum conditions to receive payments for integrated production, the so-called 'ecological standard' of performance. They must provide evidence that nutrient use matches crop demands, with livestock farmers having to sell surplus manures or reduce livestock numbers. Soils must be protected from erosion, and erosive crops, such as maize, can only be cultivated if alternated in rotation with meadows and green manures. At least 7 per cent of the farm must be allocated for species diversity protection through so-called ecological compensation areas, such as unfertilized meadows, hedgerows and orchards. Finally, pesticide use is restricted. A vital element of the policy process is that responsibility to set, administer and monitor is devolved to cantons, farmers' unions and farm advisors, local bodies and non-government organizations. By the end of the 1990s, 85 per cent of farmland complied with the basic ecological standard, which allows farmers to receive public subsidies. Some 5000 farms are now organic, and all farmers are soon expected to meet the 'ecological standard'. Pesticide applications have fallen by a third in a decade, phosphate use is down by 60 per cent and nitrogen use by half. The land under semi-natural habitats has expanded during the decade, from 1 to 6 per cent in the plains, and from 7 to 23 per cent in the mountains.

There is much to learn from these experiences of Switzerland and Cuba, as these remain the only two countries at the turn of the century who had put sustainable agriculture at the centre of their national policy. It is also true that Switzerland is wealthy and can afford these new payments to farmers for extra services, and that Cuba had no choice – it could not afford to do anything else. It is difficult to draw wide conclusions from these two cases. However, as American farmer and poet Wendell Berry has put it about his own country, 'I cannot see why a healthful, dependable, ecologically sound farm- and farmer-conserving agricultural economy is not a primary goal of this country.' Is there the political will in all the remaining 200 or so countries? The options are available, and the net benefits would be substantial. To date, the words have been easy, but the practice much more difficult.

Concluding comments

In this chapter, I have adopted a fairly narrow economic perspective to set out some of the real costs of modern agricultural and food systems. The side effects, or externalities, of food production systems are substantial, yet these do not appear in the price of food. The costs of lost biodiversity, water pollution, soil degradation and ill health in humans are shifted elsewhere in economies and, because they are difficult to identify and measure, they are easily lost. Allocating monetary values to these externalities is only one part of the picture, as these methods are inevitably inexact, but they do illustrate the size of the problem. The term multifunctional, when applied to agriculture, implies a system that does more than just produce food. Agriculture shapes landscapes, water quality, biodiversity and carbon stocks in soils. All of these are important public goods, and represent new income opportunities for farmers. But progress is slow, as policy reforms have lagged behind. There is a need for radical integration of policies to support transitions towards agricultural systems that minimize their external costs and maximize their positive side-effects.

Notes

1 On the cheapness of food, Donald Worster recognized this about a decade ago: 'the farm experts merely assume, on the basis of marketplace behaviour, that the public wants cheapness above all else. Cheapness, of course, is supposed to require abundance, and abundance is supposed to come from greater economies of scale, more concentrated economic organisation, and more industrialised methods. The entire basis for that assumption collapses if the marketplace is a poor or imperfect reflector of what people want' (Worster, 1993, p87).

2 See Astor and Rowntree (1945, p33, p47).

3 For more on George Stapledon, see Conford, 1988, pp192–193, pp196–197.

4 Despite my regular use of these five terms as capitals, I agree with the misgivings that many have. Capital implies an asset, and assets should be looked after, protected and built up. But as a term, capital is problematic for two reasons. It implies measurability and transferability. Because the value of something can be assigned a single monetary value, then it appears to matter not if it is lost, as we could simply allocate the required money to buy another, or transfer it from elsewhere. But we know this must be nonsense. Nature, and its cultural and social meanings, is not so easily replaceable. It is not a commodity, reducible only to monetary values. Nonetheless, as terms, natural capital and social capital have the uses in helping to reshape thinking around basic questions such as what is agriculture for, and what system works best? For further discussions, see Benton, 1998; Bourdieu, 1986; Coleman, 1988, 1990; Putnam, 1995; Costanza et al, 1997 and 1999; Carney, 1998; Flora, 1998; Grootaert, 1998; Ostrom, 1998; Pretty, 1998; Scoones, 1998; Uphoff, 1998; Pretty and Ward, 2001.

5 Worster, 1993, p92. See also Michael Neuman of Texas A&M University, who resolves the concept of sustainability into four very simple and compelling ideas: the rates of consumption, rates of production, rates of accumulation and depletion, and rates of assimilation.

6 See Pretty, 1998; FAO, 1999; Conway and Pretty, 1991; Altieri, 1995; Pingali and Roger, 1995; Conway, 1997.

7 For more on sustainable agriculture definitions and principles, see Altieri, 1995, 1999; Thrupp, 1996; Conway, 1997; Pretty, 1995a, 1998; Drinkwater et al, 1998; Tilman, 1998; Hinchliffe et al, 1999; Zhu et al, 2000; Wolfe, 2000.

8 An externality is any action that affects the welfare of or opportunities available to an individual or group without direct payment or compensation, and may be positive or negative. See Baumol and Oates, 1988; Pearce and Turner, 1990; EEA, 1998; Brouwer, 1999; Pretty et al, 2000. Economists distinguish between 'technological' or physical externalities, and 'pecuniary', or price effect, externalities. Pecuniary externalities arise, for example, when individuals or firms purchase or sell large enough quantities of a good or service to affect price levels. The change in price levels affects people who are not directly involved in the original transactions, but who now face higher or lower prices as a result of those original transactions. These pecuniary externalities help some groups and hurt others, but they do not necessarily constitute a 'failure' of the market economy. An example of a pecuniary externality is the rising cost of housing for local people in rural villages that results from higher-income workers from metropolitan areas moving away from urban cores and bidding up the price of housing in those villages. Pecuniary externalities are a legitimate public concern, and may merit a public policy response. Technological externalities, however, do constitute a form of 'market failure'. Dumping pesticides sewage into a lake, without payment by the polluter to those who are adversely affected, is a classic example of a technological externality. The market 'fails' in this instance, because more pollution occurs than would be the case if the market or other institutions caused the polluter to bear the full costs of its actions. It is technological externalities that are commonly simply termed 'externalities' in most environmental literature (see Davis and Kamien, 1972; Common, 1995; Knutson et al, 1998).

9 For more on the value of nature's goods and services, see Abramovitz, 1997; Costanza et al, 1997 and 1999; Daily, 1997; and the whole issue of *Ecological Economics*, 1999, volume 25, issue 1.

10 See Pimentel et al, 1992, 1995; Rola and Pingali, 1993; Pingali and Roger, 1995; Evans, 1995; Steiner et al, 1995; Fleischer and Waibel, 1998; Waibel and Fleischer, 1998; Bailey et al, 1999; Norse et al, 2000. The data from these studies are not easily comparable in their original form as different frameworks and methods of assessment have been used. Methodological concerns have also been raised about some studies. Some have noted that several effects could not be assessed in monetary terms, whilst others have appeared to be more arbitrary (e.g. the $2 billion cost of bird deaths in the US is arrived at by multiplying 67 million losses by $30 a bird: see Pimentel et al, 1992). The Davison et al (1996) study on Netherlands agriculture was even more arbitrary. It added an estimate of the costs farmers would incur to reach stated policy objectives, and these were based on predicted yield reductions of 10–25% arising from neither cheap nor preferable technologies, which led to a large overestimate of environmental damage (see Bowles and Webster, 1995; Crosson, 1995; Pearce and Tinch, 1998; van der Bijl and Bleumink, 1997).

11 On the effects of pesticides in rice, see Rola and Pingali, 1993; Pingali and Roger, 1995.

12 Hartridge and Pearce, 2001.

13 See Pretty et al, 2000, 2001. These are likely to be conservative estimates of the real costs. Some costs are known to be substantial underestimates, such as acute and chronic pesticide poisoning of humans, monitoring costs, eutrophication of reservoirs and restoration of all hedgerow losses. Some currently cannot be calculated, such as dredging to maintain navigable water, flood defences, marine eutrophication and poisoning of domestic pets. The costs of returning the environment or human health to pristine conditions were not calculated, and treatment and prevention costs may be underestimates of how much people might be willing to pay to see positive externalities created. The data also do not account for time lags between the cause of a problem and its expression as a cost, as some processes long since stopped may still be causing costs; some current practices may not yet have caused costs, and this study did not include the externalities arising from transporting food from farms to manufacturers, processors, retailers and finally to consumers.

14 See Pretty et al, 2001.

15 The government's Office of the Director General of Water Services sets industry price levels each 5 years, which determine both the maximum levels of water bills and specifies investments in water quality treatment. During the 1990s, the water industry undertook pesticide and nitrate removal schemes, resulting in the construction of 120 plants for pesticide removal and 30 for nitrate removal (Ofwat, 1998). Ofwat estimates that water companies will spend a further £600 million between 2000 and 2005 on capital expenditure alone due to continuing deterioration of 'raw water' quality due to all factors. Ofwat predicts capital expenditure for pesticides to fall to £88 million per year at the end of the 1990s/early 2000s; and for nitrate to fall to £8.3 m/yr. Although Ofwat has sought to standardize reporting, individual companies report water treatment costs in different ways. Most do distinguish treatment for pesticides, nitrate, *Cryptosporidium* and several metals (iron, manganese and lead). The remaining treatment costs for phosphorus, soil removal, arsenic and other metals, appear under a category labeled 'other'. Of the 28 water companies in England and Wales, three report no expenditure on treatment whatsoever; and a further three do not disaggregate treatment costs, with all appearing under 'other'. Twenty companies report expenditure on removal of pesticides, 11 on nitrates, and 10 on *Cryptosporidium*. It is impossible to tell from the records whether a stated zero expenditure is actually zero, or whether this has been placed in the 'other' category. Using Ofwat and water companies' returns, we estimate that 50% of expenditure under the 'other' category refers to removal of agriculturally-related materials.

16 We originally calculated the annual external costs of these gases to be £280 million for methane, £738 million for nitrous oxide, £47 million for carbon dioxide and £48 million for ammonia. But a more appropriate measure would have been to use an accepted policy target for these costs, such as the 25% cut required to meet agreements made in the Kyoto Protocol. This would put the total annual costs at £314 million.

17 DETR, 1998a, 1998b; Pretty, 1998; Campbell et al, 1997; Pain and Pienkowski, 1997; Mason, 1998; Siriwardena et al, 1998; Krebs et al, 1999.

18 Repetto and Baliga, 1996; Pearce and Tinch, 1998; HSE, 1998a, 1998b; Pretty, 1998.

19 Fatalities from pesticides at work in Europe and North America are rare – one a decade in the UK, and eight a decade in California. In the UK, a variety of institutions collect mortality and morbidity data, but in California, where there is the most comprehensive reporting system in the world, official records show that 1200–2000 farmers, farmworkers and the general public are poisoned each year (see CDFA, passim; Pretty, 1998). There appears to be greater risk from pesticides in the home and garden where children are most likely to suffer. In Britain, 600–1000 people need hospital treatment each year from home poisoning.

20 On food poisoning in the UK, see PHL, 1999; Evans et al, 1998; Wall et al, 1996. For a study of foodborne illnesses in Sweden, see Lindqvist et al, 2001. When BSE was first identified in late 1986, research confirmed that it was a member of a group of transmissible diseases occurring in animals and humans. It appeared simultaneously in several places in the UK, and has since occurred in native born cattle in other countries. By mid-2001, more than 180,000 cases had been confirmed in the UK, the epidemic having reached a peak in 1992. The link between bovine spongiform encephalopathy (BSE) and variant Creutzfeldt-Jakob Disease (CJD) in humans was confirmed in 1996, and 100 deaths from CJD have occurred to 2001. The annual external costs of BSE were £600 million at the end of the 1990s. See NAO, 1998; WHO, 2001. By mid-2001, there had been 181,000 cases of BSE reported in the UK, 648 in Ireland, 564 in Portugal, 381 in Switzerland, 323 in France, 81 in Germany, 46 in Spain and 34 in Belgium. For more on the important lessons of BSE, see Lobstein et al, 2001; Millstone and van Zwanenberg, 2001.

21 For an excellent review of food crises and the need for new thinking in food systems, see Lang et al, 2001. Also see Waltner-Toews and Lang, 2000.

22 Donald Worster (1993, p18) points out that this was not, of course, the end of the story. Control through the levees did not stop conflicts between farmers wanting water for irrigation, and others wanting to provide waterfowl with a habitat. Nor did they stop pesticides and nutrients running

off the fields. Nor did they stop the emergence livestock feedlots with their massive production of animal wastes.

23 On the effects of changes in the German landscape on flooding, see van der Ploeg et al, 1999, 2000. Vo-Tong Xuan, Rector of Angiang University in Vietnam notes similar problems in the Mekong Delta, where farmers have switched from one crop of floating rice per year to three short duration crops of modern varieties, which has led to an occurrence of floods on an annual basis.

24 On the effects of landscape, in particular paddy rice, on water control in Japan, see Minami et al, 1998; Kato et al, 1997; OECD, 2000.

25 On the externalities of Chinese agriculture, see Cai et al, 1999; Norse et al, 2000.

26 FAO, 2000.

27 On the values of wetlands, see Heimlich et al, 1998. For a study of eutrophication costs, see Pretty et al, 2001a, *A Preliminary Assessment of the Environmental Damage Costs of Eutrophication of Fresh Waters in England and Wales*. See also Postel and Carpenter, 1997 Ewel, 1997. For a study showing that the costs of creating wetlands is less than for constructing treatment plants, see Gren, 1995.

28 See Keeny and Muller, 2000.

29 We distinguished between value-loss costs arising from the reduced value of clean or non-eutrophic (nutrient-enriched) water, and the direct costs incurred in responding to eutrophication plus the costs of changing behaviour and practices to meet legal obligations. Value-loss costs, by definition, represent a loss of existing value, rather than an increase in costs, and are divided into two categories: use values and non-use values. Use values are associated with private benefits gained from actual use (or consumption) of ecosystem services, and can include private sector uses (e.g. agriculture, industry), recreation benefits (e.g. fishing, water sports, bird watching), education benefits, and general amenity benefits. Non-use values are of three types: option values, bequest values and existence values. See Pretty et al, 2001; also Mason, 1996; Environment Agency, 1998.

30 Total fertilizer consumption (N, P and K) for the world was 138 million tonnes in the year 2000, comprising 83mt of nitrogen, 32mt of phosphate, and 22mt of potassium. Nitrogen consumption in western Europe was 17mt, in North America 21mt, in South Asia 21mt, in the Russian states 38mt and in China 38mt. World consumption of all fertilizer has grown from 30mt in 1960 (when nitrogen consumption was 11mt, phosphate 11mt and potassium 8mt). Data from the International Fertilizer Industry Association, Paris.

31 WHO, 1998, *Obesity. Preventing and Managing the Global Epidemic*. Also see Oster et al, 1999.

32 See WHO, 2001.

33 For details of foodborne illnesses, see CDC, 2001; Kaeferstein et al, 1997; Mead et al, 1999. For USDA data on microbial infections in farm animals, see USDA, at www.usda.fsis.usda.gov. For costs of antibiotic resistance, see National Institute of Allergy and Infectious Diseases, at www3.niaid.nih.gov. For Centers for Disease Control, see CDC, at www.cdc.gov.

34 See Buzby and Robert, 1997; WHO, 2001.

35 For more on antibiotics and the emergence of resistance, see Harrison and Lederberg, 1998; Wise et al, 1998; House of Lords, 1999.

36 See Havelaar et al, 2000; WHO, 2001; FAO, 2001.

37 See Willis et al, 1993; Foster et al, 1997; Stewart et al, 1997; Hanley et al, 1998.

38 See Cobb et al, 1998.

39 Data is from the Countryside Agency and English Tourism Council surveys – 1968 million day and tourist-days were spent in the UK in 1998, of which 433 million were to the countryside, 118 million to the seaside and 1299 million to towns.

40 IATP, 1998.

41 Watershed Agricultural Council. Catskill/Delaware Watershed Complex, at iatp.org/watersheds.

42 Pretty and Ball, 2001

43 See Pretty and Ball, 2001; Swingland et al, 2002

44 Growing empirical evidence on the costs of compliance with environmental regulations and taxes suggest that there has been little or no impact on the overall competitiveness of businesses or

countries, with some indications that they have increased efficiency and employment. See EEA, 1996, 1999; Smith and Piacentino, 1996; Ekins, 1999; OECD, 1997a; Jarass and Obermair, 1997; Rayement et al, 1998; DETR, 1999; Ribaudo et al, 1999.

45 See Ekins, 1999, for comprehensive review of environmental taxes.

46 See Myers, 1998; Potter, 1998; Dumke and Dobbs, 1999; Hanley and Oglethorpe, 1999.

47 For more on Cuba, see Rosset, 1997, 1998; Funes, 2001.

48 Swiss Agency for Environment, Forests and Landscape and Federal Office of Agriculture, 1999, 2000. Also see Dubois et al, 2000.

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3

External Costs of Agricultural Production in the United States

Erin M. Tegtmeier and Michael D. Duffy

Introduction

All agricultural practices impact the environment. Industrial agriculture is increasingly being recognized for its negative consequences on the environment, public health and rural communities. Soil loss and erosion reduce crop yields and impair natural and manmade water systems (Atwood, 1994; Clark et al, 1985; Crosson, 1986; Evans, 1996; Holmes, 1988; Pimentel et al, 1995). Runoff of agricultural chemicals from farm fields contaminates groundwater and disrupts aquatic ecosystems (Conway and Pretty, 1991; Pimentel et al, 1992; Pretty et al, 2003; USDA, 2000d; Waibel and Fleischer, 1998). Monocropping and feedlot livestock production threaten diversity and may increase foodborne pathogens and antibiotic resistance in humans, as well as pest resistance to chemical controls (Altieri, 1995; Iowa State University and The University of Iowa Study Group, 2002; National Research Council, 1989). The health of rural communities is affected negatively by declining community involvement and increased division of social classes (Bollman and Bryden, 1997; Flora et al, 2002).

The costs of impacts are external to agricultural systems and markets for products. They are borne by society at large. Assessing the monetary costs of such impacts aids in fully identifying their consequences. Cost estimates can inform and guide policy makers, researchers, consumers and agricultural producers and may encourage a closer look at the impacts of industrial agriculture.

According to Western neoclassical economics, well-defined property rights ensure that an owner benefits exclusively from use of property and wholly incurs the costs of use. However, in many circumstances, costs are borne by those who are not decision makers. Impacts of agriculture involve costs to individuals and communities who are not making decisions about production methods. These consequences indicate when property rights are not well defined and they represent

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market failures, which lead to economic inefficiencies. In an unregulated situation, a polluter will weigh the private costs and benefits of an action, producing too much pollution with too little cleanup or producing too much product at too low a price (Miranowski and Carlson, 1993; Samuelson and Nordhaus, 1995).

Because these effects occur outside the marketplace, they are called externalities. 'Negative' externalities occur when costs are imposed; 'positive' externalities occur when others gain benefits without charge. To identify forces resulting in externalities and actions that may mitigate their effects, economists distinguish types of externalities. They can be broadly classified by the nature of their consumption (public *vs* private) and by their effects on resource allocation (pecuniary *vs* technological).

An externality is 'consumed' by those affected by it. Many externalities have the characteristic of a public good (or bad) where consumption by one individual does not reduce the good's availability to others nor the utility of consumption received by others (Baumol and Oates, 1988). For example, polluted air or scenic views are experienced in this way. They are public and undepletable and are not exchanged in the marketplace where each consumer can be charged for use. A private externality, however, is depletable. If an individual dumps trash onto another's property, this affects only the victim (Baumol and Oates, 1988). Externalities that affect public goods are of greater policy interest because there are fewer 'defensive activities' available to victims.

Externalities also are differentiated by whether the competitive marketplace can adjust to their effects. In the context of agriculture, soil erosion is a technological externality, whereas the decline of rural communities as a consequence of the character and structure of large, industrial farms is considered pecuniary. Research has described declines in purchases from local businesses, increases in crime and civil court cases and decreased property values (Flora et al, 2002). These effects, although undesirable, are not results of market failure in the neoclassical sense. They are, rather, results of the market responding to changes in supply and demand.

Economists and policy makers rely on valuation, or the process of assigning economic value, to apply the concept of externalities. A monetary metric provides a base for comparisons to aid in policy decisions. Externalities, however, often are highly complex and difficult to delineate. Even though assumptions are necessary, economists continue to refine techniques and view valuation as a way of revealing problems with the status quo.

A key assumption underlying valuation is that economic value of an object or service is derived through a function that contributes to human well-being and can be measured by 'establishing the link between that function and some service flow valued by people' (Freeman, 1998, p305). Measurement is based on the concepts of willingness to pay (WTP) for the improvement of an object or service or willingness to accept compensation (WTAC) for its deterioration (Farber et al, 2002; Hanley et al, 1997). Valuation approaches generally fall into two categories: direct survey methods and indirect methods (Hanley et al, 1997; Zilberman and Marra, 1993). Survey techniques seek to measure individual preferences for improvement in a situation or loss of well-being associated with a condition. Indirect valuation methods observe behaviour in related markets and use such data as proxies.

In all valuation efforts, sufficient and reliable data are a concern. People who are surveyed often do not have well-defined preferences to which they can assign value or they simply may not be familiar with the services provided by an environmental resource (Hanley et al, 1997). Also, value for many resources is composed of both use values and non-use values that may be particularly difficult to delineate (Hanley et al, 1997). Non-use values include existence value (the value of knowing a thing merely exists, regardless of intent to use) and option value (the value of preserving a resource for possible future use).

We continue to learn about the intricacies of ecosystems on a societal level, but critical data that would strengthen current indirect valuation projects often are not available. Also, environmental externalities, especially those associated with agriculture, frequently have broad spatial and temporal effects, adding to the complexity of valuation efforts.

Study Framework

This study assembles available valuation data to arrive at an aggregate, national figure for particular external costs of agricultural production in the US. We focus on technological externalities with public goods characteristics. A literature review revealed data on such externalities in three broad damage categories:

- natural resources (composed of water, soil and air subcategories);
- wildlife and ecosystem biodiversity;
- human health (composed of pathogen and pesticide subcategories).

A study on the total external costs of agriculture in the UK (Pretty et al, 2000) guided our work. Pretty et al compiled data from various datasets and studies to estimate costs, categorized by damages to natural capital and human health. They calculated costs of £208 per hectare of arable land and permanent pasture. This figure is higher than the cost per cropland hectare for the US reported here. The difference, in part, may be due to the inclusion of costs of the BSE (bovine spongiform encephalopathy or 'mad cow') crisis and the difference in agricultural land area. Also, the UK study included costs to public agencies for monitoring and administering environmental and public health programmes associated with agriculture.

We collected programme costs in the form of agency budgets, but decided not to incorporate them into our total cost figure. This is not meant to diminish the research and conclusions of Pretty et al. But, considering the available data for direct costs, we feel that using programme costs as proxies could be viewed as double counting. And, as Pretty et al acknowledge, such activities may be necessary for any type of agricultural production. However, programme costs would likely decrease if agriculture were more environmentally benign.

Other studies on agricultural cost accounting in the UK include Adger and Whitby (1991, 1993) and Hartridge and Pearce (2001). Estimates can be found for other European countries as well: Denmark (Schou, 1996), France (Bonnieux et al, 1998; le Goffe, 2000; Piot-Lepetit et al, 1997) and Italy (Tiezzi, 1999). A discussion on integrating agricultural externalities for a number of countries in the EU can be found in Brouwer (1999).

For the US, work has been done by Faeth and Repetto (1991), Hrubovcak et al (2000), Smith (1992) and Steiner et al (1995). The study by Steiner et al is the most comparable to our research in that it compiles available data on national estimates of agricultural externalities. Our analysis relies on some of the same sources, indicating how the lack of current, available data limits investigation. Steiner et al (1995, p210) also acknowledge that external costs ideally should be calculated on a 'location-specific basis – which currently is impossible because of a lack of information'. We subsequently have found a dearth of local or regional data to qualify the national figures.

Steiner et al focused on externalities caused by pesticides, fertilisers and soil erosion and included regulatory programme costs. As reported in 1987–1990 dollars, these costs total \$1.3–3.6 billion, \$12–33 million and \$5.8–20.3 billion, respectively. In effect, we update their study and add information on the treatment of surface water for microbial pathogens, human health costs caused by foodborne pathogens and greenhouse gas emissions. We also attempt to identify, within the scope of the damage categories, a total cost figure attributable to agriculture and a cost figure per cropland hectare.

Methods

Previous studies that assign values to specific impacts of agriculture in the US form the basis of our analysis. Cost estimates are revised and updated to reflect changes in conditions and the Consumer Price Index. Final figures are in 2002 dollars.

Two points in the methodology call for further clarification. We used the Consumer Price Index as opposed to one of the other indices available because we felt that the impact of externalities would be more directly felt by consumers than producers. A second point concerns the changes in technology or production practices that may have occurred since the original estimates were made. In our calculations of damages due to soil erosion, we deflate some of the estimates by a multiplier to address the subsequent decrease in soil erosion. However, this methodology does not fully account for the changes. There really is not a clean way to make such adjustments. This issue points to the need for more updated estimates.

Cost estimates are classified according to production type (crop or livestock) and area-based external cost figures for crop production are also calculated. Agricultural land use areas reported by the US Department of Agriculture (USDA, 2000b) are used. Of 184.1 million hectares of cropland in the US, approximately

15.3 million are idled each year. The remaining 168.8 million hectares is used for area-based calculations. The external cost of crop production within each damage category is divided by 168.8 million hectares to arrive at cost per hectare figures. Area-based figures are not calculated for those external costs associated with livestock production, considering that production practices and the land areas they affect vary greatly and depend on the animal being raised.

Table 3.1 presents our resulting national tally. Table 3.2 summarizes programme budgets of agencies associated with agricultural activities. Following the tables, each damage category is further described with calculation details.

Results

(1) Damage to water resources

Impacts on water resources are gauged by the costs of treatment necessary to control major pollutants associated with agricultural production (microbial pathogens, nitrate and pesticides).

(1a) Treatment for microbial pathogens

Microorganisms in livestock waste can cause several diseases and human health problems. *Cryptosporidium* and *Giardia* are waterborne, disease-causing parasites (USDA, 2000e). They are found in beef herds and *Cryptosporidium* may be prevalent among dairy operations (Juranek, 1995; USDA, 1994, 2000d). *Cryptosporidium* oocysts have been found in 67–97 per cent of surface water sampled in the US according to the Centers for Disease Control and Prevention (CDC, 1996).

The Interim Enhanced Surface Water Treatment Rule is one of the EPA's latest rulings on microbial protection addressing *Cryptosporidium* and continuing requirements for *Giardia* and viruses. According to the EPA's Office of Water, the total annualized national cost for implementing this rule is $307 million (USEPA, 1998a). There are three potential sources of both *Giardia* and *Cryptosporidium*: wildlife, domestic livestock and humans (Pell, 1997). From this, we assume that livestock causes one-third, or approximately 35 per cent, of the damages associated with these pathogens. Applying 35 per cent to $307 million, $107.5 million of the national cost to meet the ruling may be due to livestock production. Updated from 1998 to 2002 dollars, the cost is $118.6 million.

(1b) Treatment for nitrate

Nitrate, a compound of nitrogen, can leach into groundwater sources or be carried by soil particles into surface waters via runoff. Agricultural sources of nitrate include fertilizers, livestock waste and mineralization of crop residues. Agricultural regions have been shown to be highly vulnerable to nitrate contamination of surface and groundwater (USDA, 2000d). Nitrate impairs aquatic ecosystems and is

Table 3.1 *Selected annual external cost of US agricultural production (2002, million $)*

	Damage categories	*Costs*	*C/L*[a]
1	*Damage to water resources*		
Ia	Treatment of surface water for microbial pathogens	118.6	L
Ib	Facility infrastructure needs for nitrate treatment	188.9	C
Ic	Facility infrastructure needs for pesticide treatment	111.9	C
	Category 1 Subtotal	419.4	
2	*Damage to soil resources*		
2a	Cost to water industry	277–831.1	C
2b	Cost to replace lost capacity of reservoirs	241.8–6044.5	C
2c	Water conveyance costs	268–790	C
2d	Flood damages	190–548.8	C
2e	Damages to recreational activities	540.1–3183.7	C
2f	Cost to navigation: shipping damages, dredging	304–338.6	C
2g	Instream impacts: commercial fisheries, preservation values	224.2–1218.3	C
2h	Off-stream impacts: industrial users, steam power plants	197.6–439.7	C
	Category 2 Subtotal	2242.7–13,394.7	
3	*Damage to air resources*		
3a	Cost of greenhouse gas emissions from cropland	283.8	C
3b	Cost of greenhouse gas emissions from livestock production	166.7	L
	Category 3 Subtotal	450.5	
4	*Damage to wildlife and ecosystem biodiversity*		
4a	Honeybee and pollination losses from pesticide use	409.8	C
4b	Loss of beneficial predators by pesticide applications	666.8	C
4c	Fish kills due to pesticides	21.9–51.1	C
4d	Fish kills due to manure spills	11.9	L
4e	Bird kills due to pesticides	34.5	C
	Category 4 Subtotal	1144.9–1174.1	
5	*Damage to human health – pathogens*		
5a	Cost of illnesses caused by common foodborne pathogens	375.7	L
5b	Cost to industry to comply with HACCP rule	40.7–65.8	L
	Category 5 Subtotal	416.4–441.5	
6	*Damage to human health – pesticides*		
6a	Pesticide poisonings and related illnesses	1009.0	C
	Category 6 Subtotal	1009.0	
	TOTALS:	5682.9–16,889.2 (£3256.3–9677.5 million)	

[a] C/L, refers to production type that is main cause of impact: crop or livestock.

Table 3.2 *Associated costs – agency budgets (millions $)*[a]

	Damage categories	*Costs*	*C/L*[b]
1	*Damage to water resources*		
1d	USEPA FY2003 budget requests for Nonpoint Source Programme and state grants (USEPA, 1997b, 2001a, 2002d)	153.2	C&L
4	*Damage to wildlife and ecosystem biodiversity*		
4f	USEPA FY2003 budget for Reduce Public and Ecosystem Risk from Pesticides goal (USEPA, 2002d)	21.9	C
4g	USDA FY2003 budget for Natural Resources Conservation Service (USDA, 2002b)	1260.0	C&L
4h	USDA FY2003 budget for Farm Service Agency Conservation Programmes (USDA, 2002b)	1968.0	C&L
	Category 4 Subtotal	3249.9	
5	*Damage to human health – pathogens*		
5c	USDA Food Safety and Inspection Service FY2003 budget (USDA, 2002b)	27.2	L
5d	FDA Food Safety Initiative FY2002 estimated budget (FDA, 2002)	8.4	L
5e	USDA ARS FY1999 budget for food safety, pathogen preharvest research (USDA, 2002a)	21.2	C&L
5f	USDA APHIS FY2003 budget for Plant & Animal Health Monitoring (USDA, 2002b)	143.0	C&L
5g	USDA AMS FY2003 budget for Microbiological Data Programme (USDA, 2002b)	1.5	C
	Category 5 Subtotal	201.3	
6	*Damage to human health – pesticides*		
6b	EPA Safe Food Programme FY2003 budget request (USEPA, 2002a, 2002d)	86.7	C
6c	USEPA FY2003 budget for Reduce Public and Ecosystem Risk from Pesticides goal (USEPA, 2002d)	27.7	C
6d	USDA AMS FY2003 budget for Pesticide Data Programme (USDA, 2002b)	15.0	C
	Category 6 Subtotal	129.4	
	TOTAL:	3733.8 (£2139.5 million)	

[a] Contact authors for calculation information on programme costs.
[b] C/L, refers to production type that is main cause of impact: crop, livestock or both.

a human health concern. It can be converted to nitrite in the gastrointestinal tract and may prevent the proper transport of oxygen in the bloodstream, causing methemoglobinaemia, or 'blue-baby syndrome' in infants (USDA, 2000d).

Human activities have doubled the amount of nitrogen in our ecosystems since the 1970s through atmospheric deposition of nitrogen compounds (USEPA, 2002b). Fossil fuel combustion is the primary source of nitrogen oxides (NO_x). Transportation-related sources (engines in vehicles) account for 53 per cent of these emissions, totalling 10–11 million tonnes of NO_x, and large, stationary utility and industrial boilers account for 45 per cent (USEPA, 2002b). Emissions of ammonia (NH_3) from livestock and fertilized croplands contribute to atmospheric deposition of ammonium (NH_4) (Vitousek et al, 1997, as cited in Lawrence et al, 1999). Because ammonium is highly water-soluble, it tends to be deposited closer to emission sources than nitrogen oxides.

The EPA estimated, in 1995 dollars, a total investment of $200 million was needed immediately for water treatment facilities to meet federal nitrate standards. Also, an estimated $3.3 billion is needed over 20 years to replace and maintain water system infrastructure to meet surface water, coliform and nitrate standards (USEPA, 1997a). Considering the additional cost for infrastructure maintenance, we use $200 million as an annual cost. Pretty et al estimated that 80 per cent of nitrate pollution is due to agriculture. We apply this same percentage to $200 million. In 2002 dollars, the facilities cost is $188.9 million per year.

For comparison, Crutchfield et al (1997) employed WTP survey methods to estimate the value placed on reducing nitrates in drinking water for households in four regions in the US. Estimates were $314–351 million per year.

Water treatment costs for nitrate are associated mostly with background levels of inorganic nitrogen from fertilizers. Catastrophic manure spills occur intermittently and are not considered here. Many farmers, but not all who should, appropriately credit nitrogen applied to cropland via manure.

(1c) Treatment for pesticides

Pesticides from agriculture enter surface and groundwater systems through runoff and leachate and pose risks to aquatic and human health. Approximately 447 million kilograms of active ingredients from pesticides are currently used in crop production in the US (Gianessi and Marcelli, 2000) and a number of studies have detected pesticides in water supplies (USDA, 2000d).

The EPA estimated a total need of $400 million, in 1995 dollars, for treatment facilities to meet Safe Drinking Water Act (SDWA) regulations for pesticides and other chemicals (USEPA, 1997a). Approximately 30 per cent of the chemicals listed are pesticides (USEPA, 1998b). Also, agriculture's share of national, conventional pesticide usage is 79 per cent (USEPA, 1999a). So, the $400 million figure is revised using multipliers of 30 per cent and 79 per cent. Updated to 2002 dollars, the annual cost is $111.9 million. This figure does not account for many unregulated pesticides.

Category 1 summary

Total damage to water resources due to agricultural production, according to available research, is calculated to be $419.4 million per year. Crop or livestock production is associated with these costs as follows:

- Livestock – treatment for microbial pathogens ($118.6 million);
- Crop – infrastructure needs for treatment of nitrate and pesticides ($300.8 million).

Using the above cost totals and 168.8 million hectares of cropland, water resources are impacted by cropland at a level of $1.78 per hectare annually.

This is not a complete review of all impacts on water by agricultural production. Of note, the multifaceted impacts of agricultural chemicals and sedimentation on aquatic ecosystems are not included here. The next subsection on soil resources addresses effects of sedimentation on water treatment, storage and conveyance systems. Valuation also is included for fish kills due to pesticides in Subsection 4. However, these do not fully address structural disturbances to habitats and the food chain of aquatic environments.

(2) Damage to soil resources

Agriculture practices result in soil erosion through tillage, cultivation and land left bare after harvest. After such disturbances, wind and water carry soil particles off the land. In 1997, average annual soil erosion due to water from cropland and land in the Conservation Reserve Program (CRP) was 969 million tonnes, with approximately 958 million tonnes coming off cropland. Erosion due to wind in that same year was 762 million tonnes (USDA, 2000c). Conservation efforts since 1982 have reduced soil erosion by 38 per cent on cropland and CRP land combined (USDA, 2001b), with the composition of the combined land use changing as cropland has been enrolled in the CRP. Still, agriculture remains the single largest contributor to soil erosion. To date, external costs of waterborne erosion have been studied and quantified more than those of windborne erosion. Thus, the costs that follow reflect damages due to waterborne erosion only. Because soil erosion greatly affects the condition and use of surface waters, the following costs support the need for integrated land and water policies.

Erosion reduces soil fertility, organic matter and water-holding capacity and negatively affects productivity. Environmental externalities may result with increases of fertilizer and pesticide use to counteract these effects. On-farm costs of lost productivity due to soil erosion are not included here, assuming the majority of these costs are borne by the producer. Although this is not entirely true, it is beyond the scope of this study to identify on-site effects that have off-site impacts. Some estimates of annual on-farm costs due to soil loss include $500–600 million (Crosson, 1986), $500 million to $1.2 billion (Colacicco et al, 1989) and $27 billion (Pimentel et al, 1995).

(2a) Cost to water industry

Sediment causes turbidity in water supplies and transports toxic materials, including fertilizer and pesticide residues that are bound to clay and silt particles. According to Holmes (1988), sediment contributes 88 per cent of total nitrogen and 86 per cent of total phosphorus to the nation's waterways.

Annual costs of supplying water are based on Holmes' method, using a range of treatment costs multiplied by national surface water withdrawals. Updated to 2002 dollars, Holmes' treatment costs are $26.38–78.22 per million litres. Similarly, the EPA's Office of Water (2001c) claims that the cost to treat and deliver drinking water is approximately $527.8 per million litres, 15 per cent of which goes to treatment. According to these figures, treatment costs $79.17 per million litres.

In 1995, water withdrawn for public supply was estimated at 152.174 billion litres per day, of which 63 per cent (approximately 95.87 billion litres per day) was from surface water sources (USGS, 1998).

Holmes (1988) estimated that cropland contributes 30 per cent of total suspended solids. Therefore, costs attributed to agriculture are calculated using 30 per cent of the estimate of 95.87 billion litres per day at a cost of $26.38–79.17 per million litres. Our numbers, $277–831.1 million, are likely to be conservative because treatment of groundwater sources and erosion from pastureland are not considered. However, there may be some overlap between these costs and those to meet nitrate water standards as discussed previously.

(2b) Lost capacity of reservoirs

Reservoir capacity lost to sedimentation poses a complex problem. Many existing reservoirs are irreplaceable because of unique site characteristics. Dredging is almost prohibitively expensive at a minimum cost of $2.50 per cubic metre. Additionally, there are few disposal sites for dredged material. Alternative energy sources may partially alleviate the need for reservoirs for energy production, but, in terms of water storage, the problem remains (Morris and Fan, 1998).

Although building new reservoirs may not be the realistic solution, this impact is calculated in terms of construction costs to provide some valuation of the problem. Crowder's model (1987) for assessing the cost of reservoir sedimentation is updated.

Total national water storage capacity is 627.6 billion cubic metres (Graf, 1993; Morris and Fan, 1998). Crowder (1987) reported that 0.22 per cent of the nation's water storage capacity is lost annually. Atwood (1994, as cited in USDA, 1995) examined survey records of reservoirs and lakes and found an average storage loss of 5 per cent from sediment depletion.

Construction costs for new capacity from 1963 to 1981 were $243.40–567.70 per thousand cubic metres (Crowder, 1987). Updating the median from 1981 to 2002 dollars yields $802.60 per thousand cubic metres.

Total costs are calculated using 0.2–5 per cent loss of total national capacity (627.6 billion cubic metres) at the $802.60 per thousand cubic metres replacement value. According to Crowder's analysis, 24 per cent of sediment is from cropland. Reflecting this percentage, final total costs are $241.8–6044.5 million.

(2c) Cost to water conveyance systems

Roadside ditches and irrigation canals become clogged and require sediment removal and maintenance to prevent local flooding. A cost range of $268–790 million is calculated by updating Ribaudo's (1989) figures for these categories and allotting 50 per cent for the contribution of sediment from cropland (Clark et al, 1985).

Subcategories 2d to 2h

These estimates are based primarily on the work of Clark et al (1985) who calculated total erosion effects and applied a multiplier for the percentage due to cropland appropriate to each category. However, erosion from cropland has decreased by 38 per cent since this work (USDA, 2001b). To reflect this improvement, the cropland erosion for each category is multiplied by 62 per cent and updated to 2002 dollars.

(2d) Flood damages

Sediment contributes heavily to floods and flood damages by increasing water volumes and heights and settling on property once floodwaters have abated. Figuring the percentage of flood damages that are due to sediment, as well as the percentage of sediment that is due to agricultural practices, is highly speculative, as indicated by the range of estimates.

The estimate by Clark et al of flood damages due to cropland erosion, but not including loss of life, is revised by the method discussed above to yield a range of $184.5–548.8 million. Ribaudo (1989) reported a cost range of $653–1546 million in 1986 dollars for annual damages due to soil erosion. Using 32 per cent due to cropland, as per Clark et al (1985) and updating to 2002 dollars, the revised range is $343–812 million, but this does not account for decreased erosion rates since the late 1980s.

The Federal Emergency Management Agency (FEMA) reports dollars and lives lost for billion-dollar weather disasters from 1980 to 1997 (FEMA, 2002). Average annual damages are estimated at $6.4 billion in 2002 dollars and 30 lives lost. Numerous studies have arrived at different estimates for the value of a life. An EPA document (1999b) reviews 26 studies and calculates a mean value for avoiding one statistical death to be $5.9 million. The annual cost of floods increases to $6.6 billion when using this valuation for each of the 30 lives lost. Applying percentages of flood damages due to sedimentation (9–22 per cent) and sedimentation due to cropland (32 per cent) as per Clark et al (1985), $190–465 million of this $6.6 billion could be attributable to agriculture.

This last estimate calculated from FEMA data falls within the revised range of Clark et al. High and low range estimates are eliminated as potential outliers. Also, the high end of the valuation based on Ribaudo (1989) may be dropped, considering the revision does not account for the subsequent decrease in cropland erosion. So, the range of $190–548.8 million is used in the national tally.

(2e) Cost to recreational activities

As sediment builds up in lakes and rivers, surface water recreation, including fishing, decreases. Freeman (1982) determined the costs of water pollution that affect recreation. Clark et al used these cost figures and applied a proportion due to sediment as calculated by Vaughan and Russell (1982). Not included were the costs of accidental deaths and injuries caused by increased turbidity. The range revised to 2002 dollars is $540.1–3183.7 million.

(2f) Cost to navigation

Sediment from erosion collects in navigational channels causing groundings and delays, reliance on smaller vessels and lighter loads, and damage to engines due to sand, pollution and algae.

To assess value in this category, Clark et al (1985) included only commercial shipping damages from inland groundings ($20–100 million) and costs for dredging by the US Army Corps of Engineers (USACE), which we update. Accidents and fuel or cargo spills also cause injuries and deaths and damage to public health and the environment; however, these have not been assessed here. According to the Navigation Data Center (USACE, 2003), the FY2002 cost for dredging navigational channels by the Army Corps and its contractors was $922.9 million.

Commercial shipping damages, according to Clark et al, are revised and added to an estimate of national dredging costs. Taking 32 per cent of the result to account for sedimentation from cropland (Clark et al, 1985), the final costs to navigation due to agricultural activities are approximately $304–338.6 million.

(2g) Other in-stream costs: Commercial fisheries and preservation values

Clark et al uses Freeman's (1982) estimates of benefits to commercial fisheries and preservation values that could be gained by controlling water pollution from all sources. Preservation values are non-user values, and, in this case, cleaner water provides non-users with aesthetic and ecological benefits and options for future use. As revised, these annual figures are $224.2–1218.3 million.

Sediment, with its associated contaminants and algal blooms, negatively impacts waterfront property values. A study of lakeside properties in Ohio (Bejranonda et al, 1999) figured benefits to annual rental rates of $23.22–115.90 per ac-ft ($1.88–9.40 per 100 cubic metres) were accrued by reducing the rate of sediment inflow. However, impacts of sediment on property values are not included in the tally because these values cannot be applied nationally and no other sources were found.

(2h) Other off-stream costs: Municipal and industrial users

Municipal and industrial users, including steam power plants, experience increased operational costs associated with dissolved minerals and salts remaining in water received from water treatment suppliers. To avoid scale and algae build-up in water and boiling systems, water needs to be demineralized and treated. Again using revised calculations of Clark et al, these costs are estimated at $197.6–439.7 million.

Category 2 summary

According to this research, total damage to soil resources due to agricultural production is calculated to be $2242.7–13394.7 million per year. Although waterborne erosion is considerable on western rangelands, our sources focused on cropland erosion, which is associated with all of these costs.

Using the above cost totals and 168.8 million hectares of cropland, soil resources are impacted by crop production at a level of $13.29–79.35 per hectare annually. The external cost of the eroded soil itself can be calculated by dividing the total damages due to cropland by 958 million tonnes of erosion from cropland each year. These costs range from $2.34–13.98 per tonne of eroded soil.

The damage totals for impacts on soil resources are among the highest for categories covered in this study. Perhaps, this is because a great deal of research exists on soil erosion from agriculture, which has been a long-term concern. Also, the direct effects of soil erosion may be simpler to track and analyse than damages to other categories.

(3) Damage to air resources

Agriculture damages air resources through:

- particulate matter released by soil erosion;
- volatilization of ammonia (NH_3) from urea and manure fertilizers;
- emissions of nitric oxide (NO) and nitrous oxide (N_2O) from fertilizer applications, field burning and soil denitrification;
- hazardous pollutants from manure storage at concentrated animal feeding operations (CAFOs) (Thorne, 2002);
- emissions of methane (CH_4) from enteric fermentation and eructation (belching) of ruminant livestock and manure storage (Cavigelli et al, 1998; USEPA, 2003).

Some of these releases are greenhouse gases, which interact with the environment and affect human and ecological health. They cause climate change through atmospheric warming, aggravate pulmonary and respiratory functioning, degrade building materials and contribute to the acidification and eutrophication of water resources.

Greenhouse gas emissions from agricultural sources in 2001 totalled 474.9 million tonnes carbon dioxide equivalents, which represents approximately 7 per cent of total greenhouse gas emissions in the US, including 70 per cent of all nitrous oxide emissions from anthropogenic activities and 25 per cent of total CH_4 emissions (USEPA, 2003). The net impact of agriculture is lessened by the up take of carbon by agricultural soils, and policy efforts are underway to promote practices that will increase this carbon sequestration. Agricultural soils provided a sink for 15.2 million tonnes carbon dioxide equivalents in 2001 (USEPA, 2003).

Two sources of valuation for greenhouse gases provide a range of estimates. A study by Titus (1992) considers impacts of climate change to the US, including effects on agricultural production, increases in energy consumption, sea level rise, heat-related deaths and change in forest biomass. The study calculates that a doubling of CO_2 (and equivalents) could cost \$37–351 billion per year (1992 dollars). Also, the marginal cost of climate change from burning one gallon of gasoline is calculated at \$0.16–0.36, at a 3 per cent discount rate. This translates to \$20–50 per tonne carbon dioxide equivalents (2002 dollars).

The Chicago Climate Exchange enables member corporations, municipalities and other institutions to trade greenhouse gas credits in an effort to 'determine the most cost-effective means of reducing overall emissions' (Chicago Climate Exchange, 2004). Members who have reduced emissions receive credits, which can be sold to other members. The final market price for 2003 carbon dioxide equivalents closed at \$0.98 per tonne. This is much lower than the range calculated in the Titus study. This is not surprising because the trading price is what companies are willing to pay for emission reductions and does not necessarily reflect health and environmental externalities. Also, participation in the Exchange is strictly voluntary.

However, in the interest of being conservative, we use \$0.98 per tonne carbon dioxide equivalents. As discussed, net emissions from agriculture in 2001 were 459.7 million tonnes carbon dioxide equivalents, according to the US Emissions Inventory (USEPA, 2003). Total damage from agriculture is then calculated at \$450.5 million.

EPA emission data suggest that 63 per cent of this cost is from crop production (\$283.8 million) and 37 per cent is from livestock sources (\$166.7 million), as follows:

- Crop – soil management, burning crop residues and rice cultivation;
- Livestock – enteric fermentation and manure management.

Using the above cost totals and 168.8 million hectares of cropland, air resources are impacted by cropland at a level of \$1.68 per hectare annually.

(4) Damage to wildlife and ecosystem biodiversity

These costs involve impacts to bird, fish and insect populations, which, in turn, influence ecosystem biodiversity. With approximately 447 million kilograms of active ingredients used in agricultural production (Gianessi and Marcelli, 2000), pesticides affect ecosystem balance.

Our primary valuation source is a study on the environmental impacts of pesticides by Pimentel et al (1992). We acknowledge that since this research was done formulations and application methods of some pesticides have changed to reduce toxicity. For example, the use of granular carbofuran has been severely restricted since 1994 (Pesticide Management Education Program, 1991). The EPA estimated in the 1980s that granular carbofuran killed one to two million birds each year. In spite of this, the restrictions continue to be challenged as evidenced by the recent emergency use request of rice growers in Louisiana. The EPA initially approved use of granular carbofuran on 4050 hectares, but this was reduced to 1010 hectares after public comments were received (American Bird Conservancy, 2002; National Coalition Against the Misuse of Pesticides, 2002).

Aside from the effects of pesticide use, we do include one calculation to value fish killed by manure spills. But, other known environmental stressors associated with agriculture are not represented here. These include inorganic fertilizer runoff and its impact on aquatic ecosystems and the suppression of biodiversity by monocultural practices. Again, impacts on natural ecosystems are difficult to track and analyse and valuation studies are few. Our coverage of this category is far from comprehensive.

(4a) Honeybee and pollination losses

Pollinators, especially honeybees, are fundamental to ecosystem and agricultural stability. Various studies have attempted to value the agricultural services of pollinators. Southwick and Southwick (1992) estimated \$1.6–5.7 billion in total annual benefit to agricultural consumers in the US from honeybee pollination. Morse and Calderone (2000) claim the annual value of honeybee pollination to be \$14.6 billion, in terms of increased yields and product quality.

For our purposes, the more conservative economic impact of pesticide use on honeybees as calculated by Pimentel et al (1992) is used. Their estimate of \$319.6 million is figured in terms of colony losses, reduced honey production and crop pollination and the cost of bee rentals. Assuming original reporting in 1992 dollars, the annual figure is \$409.8 million in 2002 dollars.

(4b) Loss of beneficial predators

Most pesticide applications not only affect the primary crop pest, but also natural enemies of the pest. As the population of beneficial insects drops, outbreaks of secondary pests occur, which in turn lead farmers to apply more pesticide. The cost of these additional applications and crop losses associated with secondary pests is \$666.8 million, updating the figure as per Pimentel et al (1992).

Although these costs could be considered on-site, they are included because the invertebrate loss due to broad-spectrum pesticides affects not only crop production, but also the ecosystem as a whole. In addition, pesticides may harm microorganisms. The number and activity of microorganisms in the soil are measures of soil and ecosystem health, as they break down organic matter and cycle nutrients.

(4c) Fish kills due to pesticides

Pesticides contaminate aquatic environments, poisoning fish and damaging their food sources and habitat. It is difficult to calculate losses in severe fish kill events and low-level poisonings are often not detected. Pimentel et al (1992) use EPA data to estimate 6–14 million fish deaths per year due to pesticides and values of freshwater fish from the American Fisheries Society (1982), reflecting commercial hatchery production costs of various fish species. We calculate the average of these values, omitting sturgeon and paddlefish over 38 centimetres long, at $1.67 per fish in 1980 dollars, or $3.65 in 2002 dollars. These numbers yield a damage range of $21.9–51.1 million.

(4d) Fish kills due to manure spills

Manure spills, leaks and dumping by animal feeding operations into surface waters also cause damage to aquatic environments and can be partially valued by the number of fish killed in documented events. A report by the Clean Water Network (2000) records information on feedlot spills and associated fish kills in ten states from 1995 to 1998. Most of the data were collected from state agency databases and reports. More than 13 million fish were killed in over 200 documented manure pollution events. This does not reflect the effects of smaller spills and cumulative impacts and, of course, is not a national count. However, because a high number of animal feeding operations are located in the states included in this report, these numbers are used as a rough proxy for a national estimate. Thirteen million is divided by four years and multiplied by the value of $3.65 per fish given earlier. The estimated annual cost is conservatively set at $11.9 million.

(4e) Bird kills due to pesticides

Birds exposed to pesticides may be poisoned directly or may ingest pesticide residues with prey and seeds. Pesticides affect the life cycle and reproductive ability of birds and their habitats. Toxicity is difficult to quantify, however, considering avian risk assessments customarily test only one to three bird species; the total number of bird species globally is estimated at 10,000, and over 800 species occur in the US and Canada (Mineau et al, 2001).

Pimentel et al (1992) figure approximately 672 million birds are directly exposed to pesticides on cropland and that 10 per cent of these birds die. The study provides values for a bird's life ranging from $0.40 to $216 to $800. These figures reflect, respectively, cost per bird for bird watching, hunting costs per bird felled and the cost of rearing and releasing a bird to the wild. The higher figures may be considered inappropriate because they are associated with species not as directly affected by agricultural pesticides. By updating the lowest, most conservative valuation to $0.51 per bird death, the cost of bird kills due to pesticides is $34.5 million. This total does not address life cycle and reproductive damages due to poisonings.

Category 4 summary

Total annual damage to wildlife and ecosystem biodiversity due to agricultural production, according to this research, is calculated to be $1144.9–1174.1 million. Pesticide use for crop production is associated with all of the costs, except for fish kills due to manure spills from livestock operations. These external costs can be split as follows: $1133–1162.2 million in damages due to crop production and $11.9 million due to livestock production. Considering the impacts in terms of pesticide use, each kilogram of active ingredient, of 447 million kilograms applied, generates approximately $2.55 in external costs.

Using the above cost totals and 168.8 million hectares of cropland, crop production's injuries to biodiversity cost $6.71–6.89 per hectare annually.

The external costs calculated here are substantial and suggest the need for a comprehensive examination of pesticide products and application methods. To curb manure spills, regulations for manure handling at animal feeding operations should continue to be reviewed and enforced and the promotion of other options for livestock finishing should be considered.

(5) Damage to human health: Pathogens

According to the Centers for Disease Control and Prevention (CDC), more than 250 food-transmitted diseases cause an estimated 76 million illnesses, 325,000 hospitalizations and 5200 deaths annually in the US (CDC, 2002). A Council for Agricultural Science and Technology (CAST) task force estimated microbial foodborne disease cases to number 6.5–33 million annually, with deaths possibly as high as 9000 (CAST, 1994).

Estimates for this category include costs of illnesses associated with foodborne pathogens and costs to the food industry to comply with pathogen reduction regulations. Data are not readily available for other societal costs, such as those incurred by the public health sector or from antibiotic resistance in humans. A recent CAFO air quality study in Iowa describes antibiotic resistance as 'a health threat of great concern' (Iowa State University and The University of Iowa Study Group, 2002, pp1–11).

Costs of illnesses associated with waterborne pathogens are not included because states should have implemented the Interim Enhanced Surface Water Treatment Rule (IESWTR) by 1 January 2002. The avoidance benefit of the IESWTR for *Giardia* spp. and *Cryptosporidium parvum* infections due to agriculture is estimated to be between $628 million and $1 billion annually (USEPA, 1997c, 1998a).

(5a) Cost of foodborne illnesses

Most microbial contamination stems from the processing and packaging of animal products. According to a USDA web page (2000a), 'Simple changes in food processing and handling practices can eliminate at least 90 per cent of foodborne illnesses.' This suggests that 10 per cent of foodborne pathogen contamination arises from production and meal preparation. Zero contamination is not realistic and other entry points for contamination may not be identified, so we estimate that 3 per cent of the health costs in this category are attributable to agricultural production unless otherwise noted.

Pathogens causing illness may be bacterial, parasitic, fungal or viral. Cost studies by the USDA's Economic Research Service (ERS) have focused on common bacterial agents found in meat, eggs and dairy products. Other food sources include some vegetables, fruits, juices and seafood.

The ERS estimates the annual costs for five bacterial pathogens at $6.9 billion in 2000 dollars (USDA, 2001c). These pathogens are *Campylobacter* spp., *Salmonella*, *E. coli* O157:H7, *E. coli* non-O157 STEC and *Listeria monocytogenes*. In addition to these, Buzby et al (1997) provide damage estimates for the bacteria *Clostridium perfringens* and *Staphylococcus aureus* and the parasite *Toxoplasma gondii* totalling $4.5 billion (1995 dollars). Updating these figures and attributing 3 per cent of the totals to agricultural production, the estimate for the costs of illnesses and deaths from these common pathogens is $375.7 million annually.

This is conservative given that unidentified agents cause the majority of illnesses, and estimates have been calculated only for the common, known pathogens. The CDC (Mead et al, 1999) estimates that 82 per cent of foodborne illnesses and 65 per cent of deaths are caused by unknown pathogens. Also, many illnesses go unreported or are not diagnosed as food-related.

Furthermore, these costs include only the impacts on households, in terms of lost productivity and income, medical costs and premature death. Household costs not valued include pain and disability, travel costs for medical care, loss of work time for caregivers and chronic health complications.

(5b) Cost to industry to comply with HACCP rule

In 1997, USDA's Food Safety and Inspection Service (FSIS) issued the first stage of the Pathogen Reduction/Hazard Analysis and Critical Control Point (HACCP) systems rule to meet targets for microbial pathogen reduction. FSIS cites industry costs for meat and poultry plants to comply with HACCP regulations that range from $1.3–2.1 billion in year 2000 dollars (USDA, 2001a). These estimates are based on four scenarios of different pathogen control percentages and interest rates. The estimate for costs due to agricultural production is $40.7–65.8 million, which is 3 per cent of the range of industry costs and updated to 2002 dollars. Costs of complying with HACCP may be considered health costs internalized by the food processing industry, but this 3 per cent is viewed as a cost caused by agricultural production practices, which is externalized beyond the farm gate to processors and consumers.

Category 5 summary

According to this research, damage to human health from foodborne pathogens due to livestock production is calculated at $416.4–441.5 million per year. Although contamination often originates during processing and preparation, livestock health and production methods contribute to a large number of illnesses and should be evaluated to fully address food safety issues. Growing evidence that antibiotic use in livestock increases the resistance of foodborne pathogens reinforces the need to further explore the role of production in this health threat (Iowa State University and The University of Iowa Study Group, 2002).

(6) Damage to human health: Pesticides

Pesticides endanger human health through direct exposure, release into the environment and residues on food. Exposure to pesticides, depending on toxicity and quantity, can cause poisoning, eye damage, respiratory ailments, disruption of the endocrine system (USEPA, 2002c), birth defects, nerve damage, cancer and other effects that may develop over time (USEPA, 2001c). Of particular concern are pesticides that act as endocrine disruptors:

> The endocrine system consists of a set of glands and the hormones they produce that help guide the development, growth, reproduction, and behavior of animals including human beings... EPA is concerned about the growing body of evidence that some man-made chemicals may be interfering with normal endocrine system functioning in humans and other animals. (USEPA, 1997d)

Detectable levels of pesticides have been found on approximately 35 per cent of purchased food in the US (Pimentel et al, 1992). Farm workers who handle and apply pesticides face distinct risks. More than 58,000 unintentional poisonings by agricultural pesticides were reported to the American Association of Poison Control Centers in 2002 (Watson et al, 2003).

(6a) Pesticide poisonings

Very little research has been done to identify and quantify health impacts of pesticides on a national scale for the US. Studies in the Philippines and Ecuador document health effects and calculate reduction in farmer productivity caused by pesticide use (Antle et al, 1998; Antle and Pingali, 1994; Cole et al, 2000; Crissman et al, 1994; Rola and Pingali, 1993). These results, however, are not transferable to agriculture in the US, considering differences in farmer training and production methods. Here, we rely on Pimentel et al (1992), who calculate the costs of pesticide poisonings and deaths based on hospitalizations, outpatient treatment, loss of work and fatalities due to accidental poisonings and treatment costs for pesticide-induced cancers. Their estimate of $787 million ($1009 million in 2002 dollars) is based, in part, on speculation regarding the incidence of illness and death. However, it could be regarded as conservative considering the number of poisonings reported to control centres. Also, the estimate does not include unreported or misdiagnosed illnesses or costs of chronic ailments, other than cancer, associated with pesticide exposure. In addition, detection techniques are not available for the majority of pesticides used in the US and their health effects have not been determined (Pimentel et al, 1992).

Part of this valuation may be considered double-counting with the water treatment costs in Subsection 1c. However, water treatment processes do not prevent all waterborne exposure and associated illnesses.

Category 6 summary

The cost to human health from pesticides used in crop production is $1009 million annually. Using this valuation and 168.8 million hectares of cropland, human health is affected by pesticide applications on cropland at a level of $5.98 per hectare annually. In terms of pesticide use, the impact to human health translates to $2.26 per kilogram active ingredient. This is a substantial external cost. The damages reported here and in Subsections 1 and 4 call for increased scrutiny of the human and environmental effects of chemical use in agricultural production.

In 2002, farmers spent $8.2 billion on pesticides in the US (USDA, 2004). But, this retail cost reflects less than 80 per cent of the actual cost of pesticide use, when considering the $2253.9–2283.1 million in damages to water resources, wildlife and ecosystem biodiversity and human health calculated here.

Summary

Agricultural production in the US negatively impacts water, soil, air, wildlife and human health at an estimated cost of $5.7–16.9 billion (£3.3–9.7 billion) per year. This is the aggregate cost range from the studies reviewed. The breakdown of these costs by production type, as indicated in Table 3.1, is $4969.3–16,150.5 million per year of impacts due to crop production and $713.6–738.7 million due to livestock production. With the estimate of 168.8 million hectares of cropland in the US, total external cost per cropland hectare is calculated at $29.44–95.68 (£16.87–54.82), as shown in Table 3.3 by damage category.

These figures offer a broad, preliminary view of how the externalities of agriculture encumber society. And yet, these numbers are conservative, considering we are limited by the complexities of assigning monetary values to environmental and health impacts and the lack of related data.

Table 3.3 *Annual external costs of crop production per hectare*

Damage category	*Cost*
Water resources	$1.78
Soil resources	$13.29–79.35
Air resources	$1.68
Biodiversity	$6.71–6.89
Human health – pesticides	$5.98
Totals	$29.44–95.68 (£16.87–54.82)

Comparing our findings with a more comprehensive list of agricultural externalities illustrates the incomplete nature of our national tally. For this we turn to social and natural resource accounting efforts, which attempt to incorporate human and environmental capital assets and flows into traditional income and product measures. These assets are not priced in the current market economy and require valuation to be included in social accounts. We refer the reader to other sources for further information on systems of accounts:

- *System of National Accounts* (Commission of the European Communities et al, 1993);
- *Handbook of National Accounting: Integrated Environmental and Economic Accounting* (United Nations et al, 2003);
- *A System of Economic Accounts for Food and Agriculture* (Food and Agriculture Organization, 1996);
- *Environmental Indicators for Agriculture* (Organisation for Economic Co-operation and Development, 2001).

The environmental indicators listed in Table 3.4 are a combination of those provided in *Environmental Indicators for Agriculture* and Cabe and Johnson (1990), as well as others we have suggested. Please refer to these sources for further explanation of indicators. Also shown in Table 3.4 are the categories for which we have identified national valuation data.

Table 3.4 *Agri-environmental indicators*

Indicator	*National valuation data for the US*
Nutrient use: balance, efficiency, human health risks	Water treatment for nitrates
Pesticide use and risks	Water treatment Hospitalizations, outpatient treatment, loss of work, fatalities due to accidental poisonings and treatment costs for pesticide-induced cancers
Water use: intensity, efficiency, stress	
Human health risks of production: antibiotic use, waterborne and foodborne pathogens	Water treatment for microbial pathogens Some household costs for illnesses caused by common foodborne pathogens Cost to industry to comply with HACCP rule
Soil erosion by water	For cropland erosion only:
Commercial fisheries	X
Flood damage	X
Industrial users	X
Preservation values	X
Recreation	X

Table 3.4 *(continued)*

Indicator	*National valuation data for the US*
Salinity	
Transportation/navigation	X
Water conveyance	X
Water storage	X
Water treatment	X
Soil erosion by wind	
Human health	
Soiling	
Visibility	
Ground and surface water quality: risks and state	Water treatment for pathogens, nitrates, pesticides
Land conservation	
Water retaining capacity	
Off-farm sediment flow/soil retaining capacity	
Greenhouse gas emissions	X
Biodiversity	
Genetic diversity	
Species diversity: wild, non-native	Impacts to honeybees, beneficial predators, fish, birds
Ecosystem diversity	
Wildlife habitats	
Intensively farmed agricultural habitats	
Semi-natural agricultural habitats	
Uncultivated natural habitats	
Habitat matrix	
Aquatic habitats	
Landscapes	
Structure	
Environmental features, land-use patterns	
Man-made objects/cultural features	
Management	
Costs and benefits	

Clearly, further research is needed on external costs of agriculture, including detailed studies in each impact category, by geographical region and by production type. Comparative valuation studies also would be instructive, i.e. examinations of grazing *vs* feedlot production of livestock or monocropping *vs* diverse cropping systems. In comparing production methods, trade-offs should be taken into account. For instance, lower pesticide use often requires increased tillage and possibly causes more soil erosion. Also of interest would be an examination of positive, or beneficial, externalities provided by agriculture, i.e. carbon sequestration, wildlife habitat and aesthetics. Pricing these services may open the door to policy decisions that compensate producers for such 'products'.

Conclusion

Many in the US pride themselves on our 'cheap' food. But, this study demonstrates that consumers pay for food well beyond the grocery store checkout. We pay for food in our utility bills and taxes and in our declining environmental and personal health. These costs total, conservatively, \$5.7–16.9 billion (£3.3–9.7 billion) each year. We also support at least \$3.7 billion (£2.1 billion) annually in efforts to regulate the present system and mitigate damages. Additional public costs of agricultural production in the US include direct subsidies and other support mechanisms for farmers. These are not included in our final tally but must be considered in the true cost of food.

What can be done? By using 'ecological' or 'sustainable' methods, some agricultural producers claim to be internalizing many of these external costs. However, the market and policy structure in which most producers operate offers narrow return margins and discourages changes in production methods. Considering this, the partial estimate of damage costs presented here promotes responsible, creative policy actions to acknowledge and internalize the externalities of production practices that are generally accepted and widespread.

Furthermore, the estimates presented in this chapter are conservative for reasons beyond the need for more valuation data. Many industrial agricultural practices present us with environmental risks that have unknown potential consequences. Potentialities are difficult to define because effects are diffuse in time and location. Some of these risks have been acknowledged scientifically but not necessarily politically, i.e. ecosystem behaviour in a mono-cropped environment, antibiotic resistance in humans, loss of pollinators.

Political intention is required to reassess and reform agricultural policy. Programmes that highlight sustainable methods rather than destructive, risky practices would be a start in internalizing the true costs of the present system.

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From Pesticides to People: Improving Ecosystem Health in the Northern Andes

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Introduction

Since the early 1990s, a number of national and international organizations have been working with communities in Carchi, Ecuador's northernmost province, on projects to assess the role and effects of pesticide use in potato production and to reduce its adverse impacts. These are INIAP (National Institute of Agricultural Research from Ecuador), CIP (International Potato Center), Montana State University (US), McMaster University and University of Toronto (Canada), Wageningen University (The Netherlands), and the FAO's (Food and Agriculture Organization) Global Integrated Pest Management (IPM) Facility.

These projects have provided quantitative assessments of community-wide pesticide use and its adverse effects. Through system modelling and implementation of different alternatives, we have demonstrated the effectiveness of different methods to lessen pesticide dependency and thereby improve ecosystem health. Meanwhile, the principal approach to risk reduction of the national pesticide industry continues to be farmer education through 'Safe Use' campaigns, despite the safe use of highly toxic chemicals under the social and environmental conditions of developing countries being an unreachable ideal. These conflicting perspectives and the continued systematic poisoning of many rural people in Carchi have motivated a call for international action (Sherwood et al, 2002).

The project members have worked with interested stakeholders to inform the policy debate on pesticide use at both the provincial and national levels. Our position has evolved to include the reduction of pesticide exposure risk through a combination of hazard removal (in particular, the elimination of highly toxic pesticides from the market), the development of alternative practices and ecological

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education. The experience reported here has led us to conclude that more knowledge-based and socially oriented interventions are needed. These must be aimed at political changes for enabling new farmer learning and organizational capacity, differentiated markets and increased participation of the most affected parties in policy formulation and implementation. Such measures involve issues of power that must be squarely faced in order to foster continued transformation of potato production in the Andes towards sustainability.

Potato Farming in Carchi

The highland region of Carchi is part of a very productive agricultural region, the Andean highlands throughout Northern Ecuador, Colombia and Venezuela. Situated near the equator, the region receives adequate sunlight throughout the year which, coupled with evenly distributed rainfall, means that farmers can continuously cultivate their land. As a result, the province is one of Ecuador's most important producers of staple foods, with farmers producing nearly 40 per cent of the national potato crop on only 25 per cent of the area dedicated to potato (Herrera, 1999).

Carchi is a good example of the spread of industrialized agricultural technologies in the Americas during the Green Revolution that began in the 1960s. A combination of traditional sharecropping, land reform, market access and high-value crops provided the basis for rural economic development (Barsky, 1984). Furthermore, as a result of new revenues from the oil boom of the 1970s, the Ecuadorian government improved transportation and communication infrastructure in Carchi, and the emerging agricultural products industry was quick to capitalize on the availability of new markets. A typical small farm in Carchi is owned by an individual farm household and consists of several separate, scattered plots with an average area of about six hectares (Barrera et al, 1998).

Not surprisingly, agricultural modernization underwent a local transformation. In Carchi, mechanized, agrochemical and market-oriented production technologies are mixed with traditional practices, such as sharecropping arrangements, payments in kind, or planting in *wachu rozado* (a pre-Colombian limited tillage system) (Paredes, 2001). Over the last half-century, farming in Carchi has evolved towards a market-oriented potato-pasture system dependent on external inputs. Between 1954 and 1974 potato production increased by about 40 per cent and worker productivity by 33 per cent (Barsky, 1984). Until recently, the potato growing area in the province continued to increase, and yields have grown from about 12t/ha in 1974 to about 21t/ha today, a remarkable three times the national average (Crissman et al, 1998a).

To confront high price variability in potato (by factors of 5–20 in recent years), farmers have applied a strategy of playing the 'lottery', which involves continual production while gambling for high prices at harvest to recover overall investment. Nevertheless, the dollarization of the Ecuadorian Sucre in 2000 led to triple digit inflation and over 200 per cent increase in agricultural labour and input costs over three years (World Development Index, 2003). Meanwhile, open trade with neighbouring Colombia and Peru has permitted the import of cheaper commodities. As a result of a trend towards increased input costs and lower potato prices, in 2003 Carchense farmers responded by decreasing the area planted in potato from about 15,000ha in previous years to less than 7000ha. It remains to be seen how farmers ultimately will compensate for the loss of competitiveness brought about by dollarization.

Carchi farmers of today rely on insecticides to control the tuber-boring larva of the Andean weevil (*Premnotrypes vorax*) and a variety of foliage damaging insects. They also rely on fungicides to control late blight (*Phytophtera infestans*). One economic study of pesticides in potato production in Carchi confirmed that farmers used the products efficiently (Crissman et al, 1994), and later attempts during the 1990s by an environmental non-governmental organization (NGO) to produce pesticide-free potatoes in Carchi failed (Frolich et al, 2000). After 40 years inorganic fertilizers and pesticides appear to have become an essential part of the social and environmental fabric of the region (Paredes, 2001).

Pesticide Use and Returns

Our 1990s study of pesticide use found that farmers applied 38 different commercial fungicide formulations (Crissman et al, 1998a). Among the fungicides used, there were 24 active ingredients. The class of dithiocarbamate contact-type fungicides were the most popular among Carchi farmers, with mancozeb contributing more than 80 per cent by weight of all fungicide active ingredients used. The dithiocarbamate family of fungicides has recently been under scrutiny in the Northern Andes due to suspected reproductive (Restrepo et al, 1990b) and mutagenic effects in human cells (Paz-y-Mino et al, 2002). Similar concerns have been raised in Europe and the US (USEPA, 1992; Lander et al, 2000).

Farmers use three of the four main groups of insecticides in 28 different commercial products. Although organochlorine insecticides can be found in Ecuador, farmers in Carchi did not use them. The carbamate group was represented only by carbofuran, but this was the single most heavily used insecticide – exclusively for control of the Andean weevil. Carbofuran was used in its liquid formulation, even though it is restricted in North America and Europe due to the ease of absorption of the liquid and the high acute toxicity of its active ingredient. Another 18 different active ingredients from the organophosphate and pyrethroid groups were employed to control foliage pests, though only four were used on more than 10 per cent of plots. Here the OP methamidophos, also restricted in North America due to its high acute toxicity, was the clear favourite. Carbofuran and methamidophos, both classified as highly toxic (1b) insecticides by the WHO, respectively made up 47 per cent and 43 per cent of all insecticides used (by weight of active ingredient applied). In sum, 90 per cent of the insecticides applied in Carchi were highly toxic. A later survey by Barrera et al (1998) found no significant shifts in the products used by farmers.

Most insecticides and fungicides come as liquids or wettable powders and are applied by mixing with water and using a backpack sprayer. Given the costs associated with spraying, farmers usually combine several products together in mixtures known locally as cocktails, applying all on a single pass through the field. On average, each parcel receives more than seven applications with 2.5 insecticides and/or fungicides in each application (Crissman et al, 1998a). Some farmers reported as many as seven products in a single concoction. On many occasions different commercial products were mixed containing the same active ingredient or different active ingredients intended for the same type of control. Women and very young children typically did not apply pesticides: among the 2250 applications that we documented, women made only four.

Product and application costs together account for about one-third of all production costs among the small and medium producers in the region. The benefit to yields (and revenues) from using pesticides exceeded the additional costs of using them (including only direct production costs such as inputs and labour but not the costs of externalities). Nevertheless, Crissman et al (1998a) found that farmers lost money in four of ten harvests, largely due to potato price fluctuations and price increases in industrial technologies, particularly mechanized land preparation, fertilizers and pesticides, that combined can represent 60 per cent of overall production outlays. Unforeseen ecological consequences on natural pest control mechanisms, in particular parasitoids and predators in the case of insect pests and selective pressure on *Phytophtora infestans* in the case of disease, raises further questions about the real returns on pesticides (Frolich et al, 2000). As we shall see, long-term profitability of pesticide use is even more questionable when associated human health costs to applicators and their families are taken into account.

Pesticide Exposure and Health Effects

Based on survey, observational and interview data, the majority of pesticides are bought by commercial names. Only a small minority of farmers reported receiving information on pesticide hazards and safe practices from vendors (Espinosa et al, 2003). Pesticide storage is usually relatively brief (days to weeks) but occurs close to farmhouses because of fear of robbery. Farmers usually mix pesticides in large barrels without gloves, resulting in considerable dermal exposure (Merino and Cole, 2003). Farmers and, on larger farms, day labourers apply pesticides using backpack sprayers on hilly terrain. Few use personal protective equipment (PPE) for a variety of reasons, including social pressure (e.g. masculinity has become tied to the ability to withstand pesticide intoxications), and the limited availability and high cost of equipment. As a result, pesticide exposure is high. During pesticide applications, most farmers wet their skin, in particular the back (73 per cent of respondents) and hands (87 per cent) (Espinosa et al, 2003). Field exposure trials using patch-monitoring techniques showed that considerable dermal deposition occurred on legs during foliage applications on mature crops (Cole et al, 1998b). Other studies have shown that additional field exposure occurs in the field during snack and meal breaks, when hand washing rarely occurs (Paredes, 2001).

Family members are also exposed to pesticides in their households and in their work through a multitude of contamination pathways. Excess mixed product may be applied to other tuber crops, thrown away with containers in the field, or applied around the house. Clothing worn during application is often stored and used repeatedly before washing. Contaminated clothing is usually washed in the same area as family clothing, though in a separate wash. Extent of personal wash up varies but is usually insufficient to remove all active ingredients from both the hands of the applicator and the equipment. Separate locked storage facilities for application equipment and clothing are also uncommon. Swab methods have found pesticide residues on a variety of household surfaces and farm family clothing (Merino and Cole, 2003).

Pesticide poisonings in Carchi are among the highest recorded in developing countries (Cole et al, 2000). In active poisoning surveillance, though there were some suicides and accidental exposures, most reported poisonings were of applicators. While the extensive use of fungicides causes dermatitis, conjunctivitis and associated skin problems (Cole et al, 1997a), we focused our attention on neurobehavioural disorders caused by highly toxic methamidophos and carbofuran. The results were startling.

The health team applied a WHO recommended battery of tests to determine the effects on peripheral and central nervous system functions (Cole et al, 1998a, 1997b). The results showed high proportions of the at-risk population affected, both farmers and their family members. Average scores for farm members were a standard deviation below the control sample, the non-pesticide population from the town. Over 60 per cent of rural people were affected and women, although not commonly active in field agriculture, were nearly as affected as field workers. Alarmingly, both Mera-Orcés (2001) and Paredes (2001) found that poisonings and deaths among young children were common in rural communities.

Contamination resulted in considerable health impacts that ranged from subclinical neurotoxicity (Cole et al, 1997a, 1998a), poisonings with and without treatment (Crissman et al, 1994) to hospitalizations and deaths (Cole et al, 2000). In summary, human health effects included poisonings (at a rate of 171/100,000 rural population), dermatitis (48 per cent of applicators), pigmentation disorders (25 per cent of applicators), and neurotoxicity (peripheral nerve damage, abnormal deep tendon reflexes and coordination difficulties). Mortality due to pesticide poisoning is among the highest reported anywhere in the world (21/100,000 rural population). These health impacts were predominantly in peri-urban and rural settings. This high incidence of poisoning may not be because the situation is particularly bad in Carchi, but because researchers sought systematically to record and document it.

Acute pesticide poisonings led to significant financial burdens on individual families and the public health system (Cole et al, 2000). At the then current exchange rates, median costs associated with pesticide poisonings were estimated as follows: public health care direct costs of \$9.85/case; private health costs of \$8.33/case; and lost time indirect costs for about six worker days of \$8.33/agricultural worker. All of these were over five times the daily agricultural wage of about \$1.50 at the time (1992). Antle et al (1998a) showed that the use of some products adversely affects farmer decision making capacity to a level that would justify worker disability payments in other countries. Neither group of researchers included financial valuation of the deaths associated with pesticide poisonings nor the effects of pesticides on quality of life, both of which would substantially increase the overall economic burden of illness estimates.

A Myth – the Highly Toxics can be Safely Used

Following the research results, limitations in the pesticide industry's safe use of pesticides (SUP) campaign became apparent. In a letter to the research team, the Ecuadorian Association for the Protection of Crops and Animal Health (APCSA, now called Crop Life Ecuador) noted that an important assumption of SUP was that exposure occurred because of 'a lack of awareness concerning the safe use and handling of [pesticide] products'. Although our Carchi survey showed a low percentage of women in farm families had received any training on pesticides (14 per cent), most male farmers (86 per cent) had received some training on pesticide safety practices. Furthermore, labels are supposed to be an important part of the 'hazard communication process' of salesmen. Yet our work in Carchi indicated that farm members often could not decipher the complex warnings and instructions provided on most pesticide labels.

Although 87 per cent of the population in our project area was functionally literate, over 90 per cent could not explain the meaning of the coloured bands on pesticide containers indicating pesticide toxicity. Most believed that toxicity was best ascertained through the odour of products, potentially important for organophosphates with sulphur groups but not generalizable to all products that are impregnated by formulators for marketing purposes. Hence even the universal, seemingly simple toxicity warning system of coloured bands on labels has not entered the local knowledge system. If industry is seriously concerned about informing farmers of the toxicity of its products, it should better match warning approaches to current perceptions of risk, such as considering using toxicity-related odour indicators.

In addition, the SUP campaign's focus on pesticides and PPE is misguided. Farmers regard PPE as uncomfortable and 'suffocating' in humid warm weather, leading to the classic problem of compliance associated with individually oriented exposure reduction approaches (Murray and Taylor, 2000). Examination of the components of the classic industrial hygiene hierarchy of controls (Table 4.1) shows PPE to be among the least effective controls and suggests that the industry

Table 4.1 *Hierarchy of controls for reducing pesticide exposure*

Most effective	
1	Eliminate more highly toxic products, e.g. carbofuran and methamidophos
2	Substitute less toxic, equally effective alternatives
3	Reduce use through improved equipment, e.g. low volume spray nozzles
4	Isolate people from the hazard, e.g. locked separate pesticide storage
5	Label products and train applicators in safe handling
6	Promote use of personal protection equipment
7	Institute administrative controls, e.g. rotating applicators
Least effective	

Source: Adapted from Plog et al, 1996

strategy of prioritizing PPE is similar to locking the stable after the horse has bolted. Our research has shown the ineffectiveness of product labelling (point 5). Isolation (point 4) is difficult in open environments such as field agriculture where farming infrastructure and housing are closely connected and some contamination of the household is virtually inevitable, particularly in poorer households. Priority should be given to other more effective strategies of exposure reduction, beginning with point 1: eliminating the most toxic products from the work and living environments. Likewise, this is the highest priority of the Integrated Production and Pest Management (IPPM) 2015 initiative.

INIAP, the Ecuadorian agricultural research institute, is prepared to declare that alternative technologies exist for the Andean weevil and foliage pests and that highly toxic pesticides are not necessary for potato production and other highland crops in Ecuador (Gustavo Vera, INIAP Director General of Research, personal communication). Meanwhile, pesticide industry representatives have privately acknowledged that they understand that highly toxic pesticides eventually will need to be removed from the market. Nevertheless, the Ecuadorian Plant and Animal Health Service (SESA) and Crop Life Ecuador have taken the position that they will continue to support the distribution and sale of WHO Class I products in Ecuador until the products are no longer profitable or that it is no longer politically viable to do so.

One seven-year study by Novartis (now Syngenta) found that SUP interventions in Latin America, Africa and Asia were expensive and largely ineffective, particularly with smallholders (Atkin and Leisinger, 2000). The authors argue that 'the economics of using pesticides appeared to be more important to [small farmers] than the possible health risks' (p121). The most highly toxic products are the cheapest on the market in Carchi, largely because the patents on these early generation products have expired, permitting free access to chemical formulas and competition, and because farmers have come to accept the personal costs associated with poisonings.

Policies and Trade-offs

Pesticide use in agricultural production conveys the benefit of reducing losses due to pests and disease. That same use, however, can cause adverse environmental and health impacts. Previously, we cited a study that showed that pesticide use by farmers was efficient from a narrow farm production perspective. Nevertheless, that study examined pesticide use solely from the perspective of reducing crop losses. If the adverse health and environmental effects were also included in the analysis, the results would be different. Integrated assessment is one method for solving this analytical problem. The Carchi research team devised an innovative approach to integrated assessment called the Trade-off Analysis (TOA) method (Antle et al, 1998b; Stoorvogel et al, 2004).

The TOA method is an interactive process to define, analyse and interpret results relevant to policy analysis. At its heart is a set of linked economic, biophysical and health models inside a user shell called the TOA Model. Based on actual dynamic data sets from the field, we used simulations in the TOA method to examine policy options for reducing pesticide exposure in Carchi.

The policy options we explored were a combination of taxes or subsidies on pesticides, price increases or declines in potatoes, technology changes with IPM, and the use of personal protective equipment. We examined the results in terms of farm income, leaching of pesticides to groundwater and health risks from pesticide exposure. Normally, policy and technology changes produce trade-offs – as one factor improves, the other factor worsens. Our analysis of pesticide taxes and potato price changes produced such a result. As taxes decrease and potato prices increase, farmers plant more of their farm with potatoes and tend to use more pesticide per hectare. Thus a scenario of pesticide subsidies and potato price increases produce growth in income and increases in groundwater contamination and health risks from pesticide exposure.

With the addition of technology change to these price changes, the integrated analysis produced by the TOA model showed that a combination of IPM and protective clothing could produce a win–win outcome throughout the range of price changes: neurobehavioural impairment and environmental contamination decreased while agricultural incomes increased or held steady (Antle et al, 1998c; Crissman et al, 2003).

Transforming Awareness and Practice: The Experience of EcoSalud

The unexpected severity of pesticide-related health problems and the potential to promote win–win solutions motivated the research team to search for ways to identify and break the pervasive cycle of exposure for the at-risk population in

Carchi. The EcoSystem Approaches to Human Health Program of IDRC (www.idrc.ca/ecohealth) offered that opportunity through support to a project called EcoSalud (*salud* means health in Spanish). The EcoSystem Approaches to Human Health Program was established on the understanding that ecosystem management affects human health in multiple ways and that a holistic, gender-sensitive, participatory approach to identification and remediation of the problem is the most effective manner to achieve improvements (Forget and Lebel, 2001).

The EcoSalud project in Carchi was essentially an impact assessment project designed to contribute directly to ecosystem improvements through the agricultural research process. The aims were to improve the welfare of the direct beneficiaries through enhanced neurobehavioural function brought about by reduced pesticide exposure, and to improve the well-being of indirect beneficiaries through farming innovation. The project design called for before-and-after measurements of a sample population that changed its behaviour as result of the intervention. Consistent with IDRC's EcoSystem Health paradigm, the intervention was designed to be gender sensitive and increasingly farmer- and community-led.

EcoSalud started by informing members of three rural communities of past research results on pesticide exposure and health impacts. To illustrate pesticide exposure pathways, we used a non-toxic fluorescent powder that glowed under ultraviolet light as a tracer (Fenske et al, 1986). Working with volunteers in each community, we added the tracer powder to the liquid in backpack sprayers and asked farmers to apply as normal. At night we returned with ultraviolet lights and video cameras to identify the exposure pathways. During video presentations, community members were astonished to see the tracer not only on the hands and face of applicators, but also on young children who played in fields after pesticide applications. We also found traces on clothing and throughout the house, such as around wash areas, on beds and even on the kitchen table. Perhaps more than other activities, the participatory tracer study inspired people to take action themselves.

People, in particular mothers, began to speak out at community meetings. The terms *el remedio* (the treatment) and *el veneno* (the poison) were often used interchangeably when referring to pesticides. Spouses explained that the need to buy food and pay for their children's education when work options were limited led to an acceptance of the seemingly less important risks of pesticides. They explained that applicators often prided themselves on their ability to withstand exposure to pesticides. As one young girl recounted (in Paredes, 2001):

> One time, my sister Nancy came home very pale and said that she thought she had been poisoned. I remembered that the pesticide company agricultural engineers had spoken about this, so I washed her with lots of soap on her back, arms and face. She said she felt dizzy, so I helped her vomit. After this she became more resistant to pesticides and now she can even apply pesticides with our father.

Despite stories such as this, many women became concerned about the health impacts of pesticides on their families. During one workshop, a women's group asked for disposable cameras to document pesticide abuse. Children were sent to spy on their fathers and brothers and take photos of them handling pesticides carelessly or washing sprayers in creeks. Their presentations led to lively discussions. The results of individual family studies showed that poisonings caused chronic ill-health for men and their spouses, and ultimately jeopardized household financial and social stability. Concern about the overall family vulnerability was apparent during community meetings, when women exchanged harsh words with their husbands over their agricultural practices that resulted in personal and household exposure to toxic chemicals. The men responded that they could not grow crops without pesticides and that the safer products were the most expensive. Communities called for help.

INIAP's researchers and extensionists in Carchi had gained considerable experience with farmer participatory methodologies for technology development, including community-led varietal development of late blight disease resistant potatoes. We know that such approaches can play an important role in enabling farmers to acquire new knowledge, skills and attitudes needed for improving their agriculture. INIAP built on existing relationships with Carchi communities to run Farmer Field Schools (FFSs), a methodology recently introduced to the Andes. In part, FFSs attempt to strengthen the position of farmers to counterbalance the messages from pesticide salespeople. As one FFS graduate said (in Paredes, 2001):

> Prior to the Field School coming here, we used to go to the pesticide shops to ask what we should apply for a problem. Then the shopkeepers wanted to sell us the pesticides that they could not sell to others, and they even changed the expiry date of the old products. Now we know what we need and we do not accept what the shopkeepers want to give us.

FFS have sought to challenge the most common of IPM paradigms that centres on pesticide applications based on economic thresholds and transfer of single element technologies within a framework of continuing pesticide use (Gallagher, 2000). In contrast, FFS programmes propose group environmental learning on the principles of crop health and ecosystem management as an alternative to reliance on curative measures to control pests. As a FFS graduate in Carchi noted (in Paredes, 2001):

> When we talk about the insects [in the FFS] we learn that with the pesticides we kill everything, and I always make a joke about inviting all the good insects to come out of the field before we apply pesticides. Of course, it is a poison, and we kill everything. We destroy nature when we do not have another option for producing potatoes.

In practice, the FFS methodology has broadened technical content beyond common understanding of IPM to a more holistic approach for improving plant and soil health. The FFS methodology adapts to the diverse practical crop needs of farmers, be they production, storage or commercialization. FFS ultimately aspires to catalyse the innovative capacity of farmers, as exemplified by how a graduate has improved cut foliage insect traps tested in his FFS (in Paredes, 2001):

> I always put out the traps for the Andean weevil, even if I plant 100 [bags of seed] because it decreases the number of adults. It is advantageous because we do not need to buy much of that poison Furadan. But I do use them differently. After ploughing, I transplant live potato plants from another field, then I do not need to change the dead plants every eight days.

In an iterative fashion, FFS participants conduct learning experiments on comparative (conventional *vs* IPM) small plots (about 2500m^2) to fill knowledge gaps and to identify opportunities for reducing external inputs while improving production and overall productivity. After two seasons, initial evaluation results in three communities were impressive. Through the use of alternative technologies, such as Andean weevil traps, late blight resistant potato varieties, specific and low toxicity pesticides, and careful monitoring before spraying, farmers were able to decrease pesticide sprays from 12 in conventional plots to seven in IPM plots while maintaining or increasing production (Barrera et al, 2001). The amount of active ingredient of fungicide applied for late blight decreased by 50 per cent, while insecticides used for the Andean weevil and leafminer fly (*Liriomysa quadrata*), that had commonly received the highly toxic carbofuran and methamidophos, decreased by 75 per cent and 40 per cent respectively.

Average yields for both conventional and IPM plots were unchanged at about 19t/ha but net returns increased as farmers were spending less on pesticides. FFS participants identified how to maintain the same level of potato production with half the outlay in pesticides and fertilizers, decreasing the production costs from about $104 to $80 per tonne. Because of the number of farmers involved in FFS test plots, it was difficult to assess labour demands in the economic analysis. Nonetheless, farmers felt that the increased time for scouting and using certain alternative technologies, such as the insect traps, would be compensated by decreased pesticide application costs, not to mention decreased medical care visits. A recent ex-post study that INIAP will publish in early 2004 has confirmed this trend at the level of individual farms of FFS graduates in Carchi (Barrera et al, in press).

In addition to the intensive six-month FFS experience, EcoSalud staff visited individual households to discuss pesticide safety strategies such as improved storage of pesticides, PPE, use of low volume nozzles that achieve better coverage with less pesticide, and more consistent hygienic practices. Based on widespread disinterest in PPE, we were surprised when participants began to request help in finding high quality personal protective equipment, that they said was unavailable at the dozens of local agrochemical vendors. EcoSalud staff found high quality PPE (mask, gloves, overalls and pants) through health and safety companies in the capital city, costing $34 per set, the equivalent of over a week's labour at the time. The project agreed to grant interest free, two-month credit towards the purchase price to those interested in buying the gear. Remarkably, 46 of the 66 participating families in three communities purchased complete packages of equipment. A number of farmers rented their equipment to others in the community in order to recuperate costs. Follow-up health studies are not complete, but anecdotal evidence is promising. As the wife of one FFS graduate who previously complained of severe headaches and tunnel vision due to extensive use of carbofuran and metamidophos said:

> Carlos no longer has headaches after working in the fields. He used to return home [from applying pesticides] and could hardly keep his eyes open from the pain. After the Field School and buying the protective equipment, he is a far easier person to live with (personal communication, farm family, Santa Martha de Cuba).

Complementary projects have supported follow-up activities in Northern Ecuador and elsewhere, including the production of FFS training materials (Pumisacho and Sherwood, 2000; Sherwood and Pumisacho, in press), the training of nearly 100 FFS facilitators in Carchi and nearby Imbabura, the transition of FFS to small-enterprise production groups and the establishment of farmer-to-farmer organization and capacity building. Concurrently, over 250 facilitators have been trained nationwide and hundreds of FFS have been completed. Recently, Ecuador's Ministry of Agriculture decided to include FFS as an integral part of its burgeoning national Food Security Program. Furthermore, in part due to the successful experience in Carchi, FFS methodology has subsequently spread to Peru, Bolivia and Colombia as well as El Salvador, Honduras and Nicaragua, where over 1500 FFS had been conducted by mid 2003 (LEISA, 2003).

Concluding Comments

Much conventional thinking in agricultural development places emphasis on scientific understanding, technology transfer, farming practice transformation and market linkages as the means to better futures. Consequently, the focus of research and interventions tends to be on the crops, the bugs and the pesticides, rather than the people who design, chose and manage practices. Recent experiences of rural development and community health, however, argue for a different approach (see for example, Uphoff et al, 1998; Norgaard, 1994; Latour, 1998; Röling, 2000). Of course, technologies can play an important role in enabling change, but the root causes of the ecosystem crisis such as in Carchi appear to be fundamentally conceptual and social in nature, that is, people sourced and dependent.

There is a general need for organizing agriculture around the development opportunities found in the field and in communities (van der Ploeg, 1994). Experience with people-centred and discovery-based approaches has shown promise at local levels, but ultimately such approaches do not address structural power issues behind complex, multi-stakeholder, socio-environmental issues, such as pesticide sales, spread and use.

The search for innovative practice less dependent on agrochemical markets needs to focus on the diversity of farming and the socio-technical networks that enable more socially and ecologically viable alternatives. Progress in this area would require a new degree of political commitment from governments to support localized farming diversity and the change of preconceived, externally designed interventions towards more flexible, locally driven initiatives. In addition, local organizations representing the most affected people must aim to influence policy formulation and implementation.

Our modern explanations are ultimately embedded in subtle mechanisms of social control that can lead to destructive human activity. The social and ecosystem crises common to modernity, evident in the people-pest-pesticide crises in the Northern Andes, are not just a question of knowledge, technology, resource use and distribution, or access to markets. Experience in Carchi demonstrates that approaches to science, technology and society are value-laden and rooted in power relationships among the diverse actors – such as farmers, researchers, industry representatives and government officials – that can drive farming practice inconsistent with public interest and the integrity of ecosystems. Solutions will only be successful if they break with past thinking and more effectively empower communities and broader civil society to mobilize enlightened activity for more socially and environmentally acceptable outcomes.

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5

Incidence of Acute Pesticide Poisoning Among Female and Male Cotton Growers In India

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Introduction

Agriculture in South India is primarily a subsistence production system that involves 127 million cultivators and 107 million agricultural labourers. Crop productivity in the rainfed area, which includes more than 70 per cent of the cultivated land, is low and unpredictable (Department of Agriculture, 2002). The majority of the population is rural (74.3 per cent, Census 2001) and 34.7 per cent live below the international poverty level (World Bank, 2003).

During the Green Revolution, high yielding varieties of various crops were introduced into the farming systems to increase productivity. These varieties were significantly more susceptible to plant pests and diseases and, subsequently, the use of pesticides became more intense, increasing from 2330 kton during 1950–51 to 54,773 kton in 1990–91 (Directorate of Plant Protection, 2002, personal communication). Pesticides are largely applied to protect commercial crops. Cotton cultivation alone uses more than 60 per cent of the national consumption. The consequences of such indiscriminate use of pesticides have recently become a matter of public concern in India, following the publication of alarming information about the levels of pesticide residues in drinking water and soft drinks (CSE, 2003). Beside the consumers' risks stands the documented hazard to producers, who are directly exposed to chemical substances (Kishi et al, 1995; Murphy et al, 1999; Wesseling et al, 2001; Kunstadter et al, 2001). Agricultural labourers and

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farmers work in a highly unsafe occupational environment. The pesticides used largely belong to WHO category I and II (Highly Hazardous and Moderate Hazardous). Chemical products such as Aldicarb, Dieldrin and Paraquat that are banned in developed countries are still registered in India. Protective measures and equipment for safe handling and spraying of the pesticides are far from being adopted. Instead, people work barefoot, barehanded, wearing only short-sleeved cotton tee shirts and traditional sarongs (lungi). During an average spraying session, a farmer is directly exposed to pesticides for three to four hours at a time through leaking spray equipment, dripping plants and wind drift. Concentrated chemical products are mixed with water with bare hands. Farmer risky behaviour is not necessarily explained by a lack of awareness. On the contrary, farmers' level of knowledge on the health hazards of pesticides – even though partial and inexact – is in many cases higher than expected (Aragon et al, 2001; Clarke et al, 1997; Eisemon and Nyamete, 1990; Kishi, 2002). Training does little to change hazardous use of pesticides. For example, a programme conducted by Novartis to train farmers in the safe handling and use of pesticides in the Coimbatore District of Tamil Nadu, India, in 1992 failed to achieve substantial and sustainable changes in farmers' practices. Not only is protective equipment expensive, unavailable and cumbersome to use, but in the extreme hot weather conditions of the tropics protective gear is rarely used (Kishi et al, 1995). Therefore, educating farmers about the safe use of pesticides alone does not seem to be a viable solution to eliminate occupational risks.

To date, studies have focused on the adverse health effects occurring among people applying chemical products. However, the focus should also extend to those who play supportive roles in the pesticide applications: women and children. In India, the production of cotton is female-labour-intensive. Extremely time-consuming operations such as weeding are often performed by women and children during the peak of the spraying season when there are high residue levels in the fields. Other key female tasks are pesticide mixing with water and refilling the sprayers' tanks (Mancini, unpublished).

Pesticides are largely applied by low-income groups of people, marginal farmers and landless workers. Associated malnutrition and infectious diseases in these populations makes them more vulnerable to poisoning (London and Rother, 2000; WHO, 1990). The need to generate information about the social and gender implications of pesticide application has been well documented and recommended in a review of the health impacts of pesticides complied by Kishi (2005).

This study was engendered by the need to document the serious human health consequences of the indiscriminate use of pesticides on cotton in India. The intent was to focus on less-visible, but much exposed subjects: women and marginal farmers. Women perform secondary activities that have often been neglected in studies dealing with direct exposure. Marginal farmers are often engaged in professional spraying and therefore prone to continuous exposure.

Materials and Methods

Study objectives

In 2003, the European Union Food and Agriculture Organization, Integrated Pest Management (EU-FAO IPM) Programme for Cotton in Asia designed a participatory project that aimed to assess the frequency and severity of acute pesticide poisoning among cotton growers in Andhra Pradesh. For the last three years the programme has been operative in the state educating farmers in sustainable alternatives to pesticide use in Farmer Field Schools (FFSs). As part of the regular FFS curriculum, farmers were taught of the adverse effects of pesticides on human health and the environment. The assessment was conceived as a season-long special activity to be undertaken in three villages that had IPM[1] Farmer Field Schools.[2] The initiative aimed to measure the health effects of pesticide exposure in real time through direct farmers' documentation. Because previous studies focused on male farmers who apply chemical products, this study concentrated on women as respondents (for themselves and for their male relatives). This surveillance activity assisted farmers in generating information on:

- the frequencies and severities of acute pesticide poisoning occurring among male and female cotton farmers;
- the exposure of women performing supportive roles during spray operations;
- the vulnerability of low-income groups involved in pesticide application.

A second part of the assessment undertaken in 2004 in the same villages measured actual changes occurring in the health of the respondents, as a result of the participation in the cotton IPM FFS. Monitoring continued for several months, using the same reporting method as the study reported here. The data will be analysed against the baseline survey collected in 2003.

This paper represents the first part of the assessment conducted to estimate the effects on cotton growers' health of a chemical-based plant protection system.

Study area

The study was conducted in three cotton-growing villages. They were purposely selected immediately after the commencement of the FFS – on the basis of a high female (over 50 per cent) and marginal (< 1ha) farmer (55 per cent) participation predetermined by the FFS farmer selection process and the community's interest in the monitoring activity. The EU-FAO IPM Programme adopted the strategy of conducting one FFS per village, regardless of the village size. Therefore, there were 25 trained farmers per village, of which some were women. All the women who had participated in the FFS in the three villages joined the self-monitoring. Two of the villages (Sairedapalli and Srinagar) were located in Warangal District and one (Darpalli) in Mahaboobnagar District, Andhra Pradesh.

Andhra Pradesh is one of the nine major cotton-producing states of India. The rural population is 73 per cent of the total. Cotton is grown on 1.02 million hectares. The industrial production of cottonseed is also concentrated in the state. According to the 2001 census, Mahaboobnagar and Warangal districts have a total population of 3,077,050 and 2,818,832, respectively. Cotton is grown as the main crop during the rainy season (Karif) on 121,260ha in Warangal and 22,697ha in Mahbubnagar.

Darpalli is a small village populated by marginal native farmers (721 inhabitants). The area under cotton was 45 hectares. The level of education among the people was found to be very low (in 1997, 70 per cent of the rural people in the state were not literate). In contrast, migrant communities, who moved from the state coastal area in search of fertile lands to cultivate, mainly inhabited Srinigar and Sairedapalli villages. The villages had respectively 3108 and 1038 inhabitants; the area under cotton was 500ha and 122ha. Those villages could be considered better off in that they had more education and wealth.

Training of enumerators and farmers

The study involved three FFS facilitators trained by the EU-FAO IPM Programme for Cotton in Asia in season-long (six months) residential Training of Facilitators (ToF) on IPM. In addition to the technical knowledge, the ToF provides a solid background about adult non-formal education and enables facilitators to conduct Participatory Action Research with farmers. In order to coach the self-health monitoring, three FFS facilitators were also taught how to identify the signs and symptoms of acute pesticide poisoning. Emphasis was given to the need for establishing clear correlations between illness and exposure to pesticides. Minor adaptations to the specific study requirements were made to the reporting format and method developed by Murphy et al (1999, 2002).

During the initial FFS sessions, three facilitators trained the farmers who had volunteered to participate in the monitoring. The forms to be used were field tested with 20 respondents to correct for any potential misunderstandings of the reporting procedures as well as misconceptions about the signs and symptoms. During the four months of the assessment, the project staff provided constant coaching to the farmers and the facilitators. A mid-season review meeting was also organized two months from the start. A simple analysis of the forms was done together with the farmers at the end of the season in a final workshop.

Period and procedure

The actual reporting started in the second month of the cotton-growing season when pesticides are first applied to the young plants, in August 2003, and lasted until December 2003. Women farmers (n = 50) attending the FFSs, organized in their respective villages, filled in health-monitoring forms after potential exposure to a variety of pesticides. In addition to self-reporting their own signs and symptoms of acute poisoning, the women each interviewed one male family member (n = 47) who had applied pesticides. Respondents were asked to fill in a form after every potential pesticide exposure regardless of whether or not they had experienced an adverse effect. Forms were filled in as a result of any of the following circumstances:

- spraying pesticides in the field;
- mixing chemical solution and refilling spray tanks;
- working in field sprayed within the same day.

Only the signs and symptoms that occurred during the working session or within 24 hours after exposure were recorded. At each FFS meeting the forms were reviewed.

Format

The reporting format was pictorial to facilitate participation among those who were not literate (Figure 5.1). Facilitators provided the necessary assistance to review the forms throughout the monitoring.

The form allows for the reporting of the following:

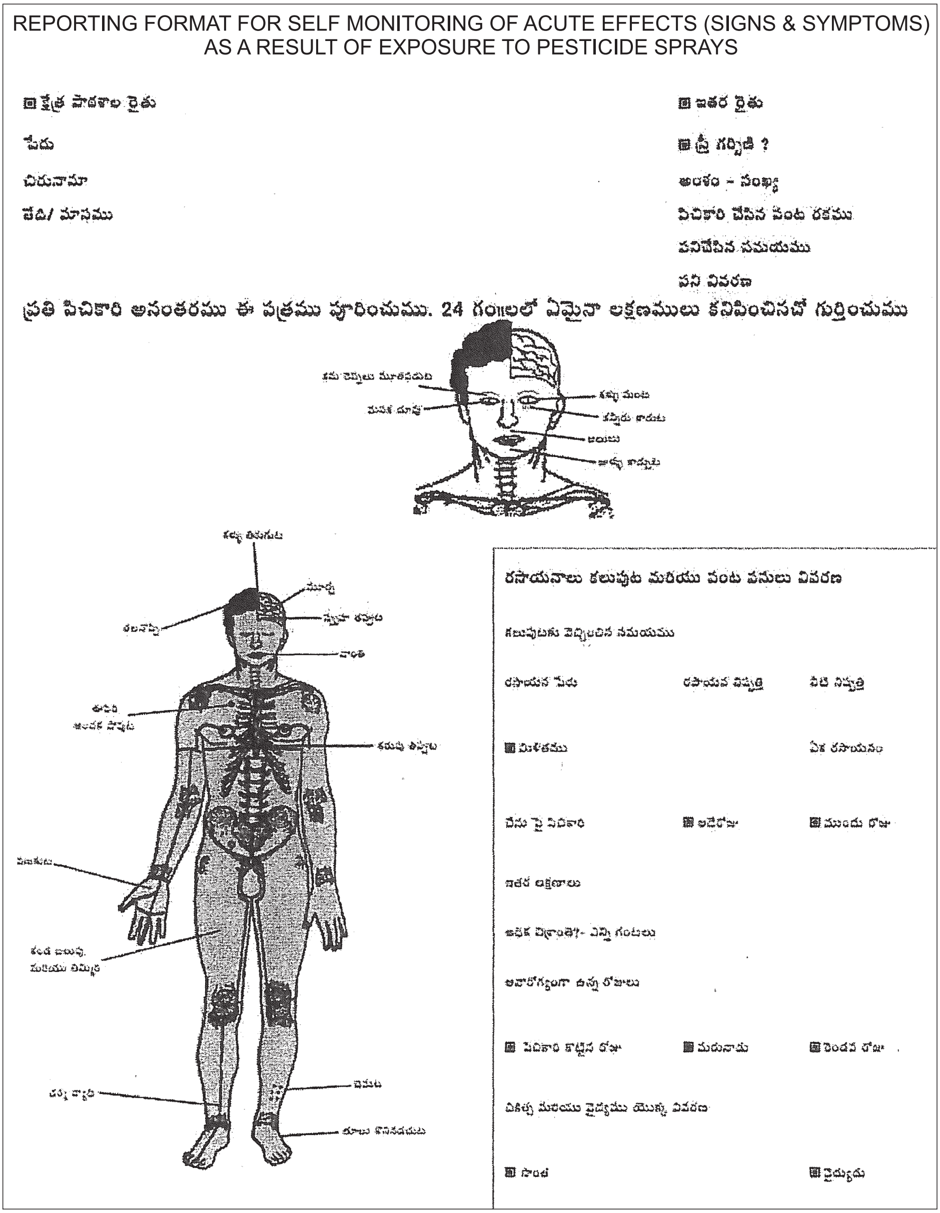
- a list of 18 signs and symptoms (S&S) of acute pesticide poisoning (see Table 5.2);[3]
- type of chemical products used;
- quantity of chemical products used (ml formulated product/Lt water);
- hours spent in performing the operation;
- hours extra-respite taken due to illness;
- number of sick days not worked as a consequence of the illness;
- use of medical treatments and home-made remedies;
- operation performed.

The following socioeconomic parameters were collected in separate interviews from each respondent: Age, Gender, Formal education, Landholding, Profession and Income level. A total of 97 farmers, 50 women and 47 men, participated in the self-health monitoring (Table 5.1). All the women participating in the FFSs in the

Table 5.1 *Distribution of respondents among the village*

	Women (respondents)	*Men (indirect reporting)*	*Total*
Darpalli	25	23	48
Sairedapalli	14	14	28
Srinagar	11	10	21
Total	50	47	97

three villages were involved in the self-monitoring. As a result of the purposive selection of the villages, the sample included 70 per cent of small farmers (<2ha).


REPORTING FORMAT FOR SELF MONITORING OF ACUTE EFFECTS (SIGNS & SYMPTOMS) AS A RESULT OF EXPOSURE TO PESTICIDE SPRAYS

క్షేత్ర పాఠశాల రైతు

ఇతర రైతు

పేరు

స్త్రీ గర్భిణి ?

చిరునామా

అంశం - సంఖ్య

తేది/ మాసము

పిచికారి చేసిన పంట రకము

పనిచేసిన సమయము

పని వివరణ

ప్రతి పిచికారి అనంతరము ఈ పత్రము పూరించుము. 24 గం॥లలో ఏమైనా లక్షణములు కనిపించినచో గుర్తించుము

రసాయనాలు కలుపుట మరియు పంట పనులు వివరణ

Figure 5.1 *Reporting format in the local language, Telegu*

Table 5.2 *List of signs and symptoms of acute pesticide poisoning*

Signs and symptoms	*Type*	*Category*
Burning eyes	Localized	1
Burning nose/tearing	Localized	1
Difficulty breathing	Systemic/neurotoxic	1
Dizziness	Systemic/neurotoxic	1
Excess sweating	Systemic/neurotoxic	1
Excessive salivation	Systemic/neurotoxic	1
Headache	Systemic/neurotoxic	1
Runny nose	Localized	1
Skin rashes	Localized	1
Blurred vision	Systemic/neurotoxic	2
Muscle cramps	Systemic/neurotoxic	2
Nausea	Systemic/neurotoxic	2
Staggering	Systemic/neurotoxic	2
Tremors	Systemic/neurotoxic	2
Twitching of eyelids	Systemic/neurotoxic	2
Vomiting	Systemic/neurotoxic	2
Loss of consciousness	Systemic/neurotoxic	3
Seizure	Systemic/neurotoxic	3

Scoring system

The forms were assigned to four categories according to the signs and symptoms (S&S) reported following Murphy's method (Murphy et al, 2002). Local effects were considered consequences of mild poisoning and rated in category 1. In the same category were some systemic or neurotoxic effects that are ill-defined (headache, dizziness, difficulty breathing) and effects that could be related to or confused with environmental factors such as heat exposure (excessive sweating, excessive salivation). The other neurotoxic effects such as nausea and vomiting, which might reflect cholinesterase depression, were classified in category 2 or moderate poisoning. Category 3 included loss of consciousness and seizure as effects of severe poisoning. Each form was assigned with a final value (severity class) equivalent to the highest category marked. Forms with no signs and symptoms marked were assigned with severity class 0 and classified as an asymptomatic event. Forms containing only category 1 effects were classified as mild acute poisoning events (Class 1). If at least one effect belonging to category 2 was included, the forms were classified as moderate poisoning events (Class 2). Finally, if one of the effects of category 3 was marked, the forms were considered an example of severe acute poisoning (Class 3). In addition to the severity class, the total sum of signs and symptoms reported in each form was also considered as an indicator of poisoning. For each form two values were therefore entered in the database as severity indicators.

- severity class;
- total number of S&S reported (#S&S).

Data analysis

Linear trend analysis (frequencies analysis and chi-square test) was performed to describe pairs of variables (men versus women and small versus large). The severity class and the #S&S were analysed in relation to the exposure variables. Multivariate analysis (multiple linear regression) was used to assess the contribution of each independent variable (Age, Gender, Formal education, Exposure Time, Pesticide Toxicity, Volume, Operation, Landholding, Income, Profession) to the severity values. Further analysis on the combination of signs and symptoms per spraying event will be performed on the complete data set at the end of the second season collection.

Results

Characteristics of the respondents

The average ages of the reporting women and interviewed men was respectively 36.5 and 37 years. The distribution by age categories is given in Table 5.3. Almost half of the respondents fell into the class 'marginal' (< 1ha) (Table 5.3). Forty-one per cent of the farmers lived below the national poverty level (10 rupees a day or 1$ per 4–5 days).

Spraying operations

Individual spraying sessions recorded in four months of monitoring totalled 392. On average, farmers filled out one form per month. However, 69 forms have been

Table 5.3 *Distribution of respondents by ages and by landholding classes*

Age	*<30*	*30–39*	*40–50*	*>50*
Women (n = 50)	18	15	17	0
Men (n = 47)	10	15	13	9
Land (ha)	*Marginal (<1)*	*Small (1–2)*	*Semimedium (2–4)*	*Medium/Large (>4)*
Women	22	11	12	5
Men	19	13	7	8

discarded due to incomplete information on the pesticides used. The distribution of the discarded forms could not be analysed and therefore biases introduced by the selection cannot be excluded. The women self-reported on 165 events and reported on 158 spraying sessions that were performed by their male relatives. The total number of forms per farmer did not reflect the individual field spraying frequency, which was separately recorded. In Darpalli village the average number of sprays for the cotton season was 5.9 (range 2–15), in Sairedapalli it was 6.4 (range 1–11) and in Srinagar 11 (range 5–14).

In the case of the women, the health forms were filled in after mixing concentrated chemicals with water and filling spray tanks (47 per cent), mixing and subsequently working in the field (24 per cent), working in a recently sprayed field (17 per cent), applying pesticides (9 per cent) and others (3 per cent). The application of pesticides referred to the spreading of phorate granules (organophosphate, WHO 1A hazard class) on maize and chilli plants.

Men's forms were filled after spraying pesticides (75 per cent), spraying and subsequently working in the field (22 per cent) as well as mixing concentrated chemicals with water and filling spray tanks (4 per cent). The average working session lasted 4h 36m for men and 4h 24m for women, an average volume respectively of 238 and 242 litres, containing 212 and 190mg of active ingredient was applied. During the study, participatory observations were conducted to better describe the gender roles of the pesticide application task. An example is given in the specific section at the end of the article.

Twenty-six types of chemicals (Table 5.4) were used. Products belonging to the organophosphate family were used in 47 per cent of the spraying events. Endosulfan (organochlorine) alone was used in 135 of the sprays.

Health effects

Reported signs and symptoms

Out of the 323 reported events 16.4 per cent were asymptomatic, 39 per cent led to mild poisoning, 38 per cent to moderate and 6 per cent to severe. Participatory evaluation is sometimes subjected to strategic bias introduced by the respondents themselves, who are centrally involved in the risk behaviours. In the case of this study, such bias would have led to an over-reporting of the health effects. In order to assess the validity of the respondents' reporting, three symptoms (excessive tearing, excessive salivation and tremor) specific to organophosphate (OP) exposure were used as dummy symptoms. Tremor was associated with OP exposure in 83 per cent of the cases, excessive tearing in 62 per cent and excessive salivation in 60 per cent. According to the respondents, endosulfan (organochlorine) was responsible for 28 per cent of the excessive tearing, 12 per cent of excessive salivation and 8 per cent of tremor (1 case). The remaining cases were explained by exposure to chloro-nicotinyl, a relatively new chemical class of systemic insecticides that act on the central nervous system. Organochlorines do not stimulate glands and therefore are not expected to cause the above mentioned symptoms. However, the relatively

Table 5.4 *List of pesticides used by the reporting farmers in cotton cultivation in India**

Pesticide	*WHO hazard class*	*Chemical family*	*Cholinesterase Inhibitor*	*% of all pesticides*
Parathion	1A	Organophosphate	+	0.3
Monocrotophos 36% SL	1B	Organophosphate	+	12
Phorate 10% G	1B	Organophosphate	+	3.7
Triazophos 40% EC	1B	Organophosphate	+	0.6
Chlorpyriphos 20% EC	2	Organophosphate	+	10
Cypermethrin 25% EC	2	Pyrethroid		8
Dimethoate 30% EC	2	Organophosphate	+	0.6
Endosulfan 35 EC	2	Organochlorine		13
Fipronil	2			0.6
Lambda cyhalothrin 5% EC	2	Pyrethroid		0.6
Phosalone 35 EC	2	Organophosphate	+	1.3
Profenophos 50% EC	2	Organophosphate	+	4
Quinalphos 25% EC	2	Organophosphate	+	13.7
Acephate 75% SP	3	Organophosphate	+	4.3
Acetamiprid 70% WP	3	Chloro-nycolil		4.6
Copper oxychloride 50% WP	3	Inorganic		1.3
Dicofol 18.5%	3	Organochlorine		0.6
Fenvalerate 20% EC	3	Pyrethroid		0.3
Imidachloprid 17.8% SL	3			4.7
Malathion 50% EC	3	Organophosphate	+	0.3
Carbendazin	U	Azole		0.6
Indoxacarb 14.5% SC	U	Chloro-nycotil		4.7
Mancozeb 75% WP	U	Carbamate	+	0.3
Spinosad 45% SC	U	Macrobial		2
Sulfur 80% WP	U	Inorganic		0.6
Wafarin 0.025%	U	Coumarin		0.6
Others (botanical, inorganic, unidentified ingredient)				7.0

* The WHO hazard classification refers to the formulated chemical products. The classification of the formulations was based on toxicity data obtained on that formulation by the manufacturer. In the cases in which this was not available, the values were calculated on the basis of the LD_{50} oral or dermal toxicity using WHO conversion tables (IPCS, 2000–2002). 1A = extremely hazardous, 1B = highly hazardous, 2 = moderately hazardous, 3 = slightly hazardous, U = unlikely to present acute serious hazard in normal use.

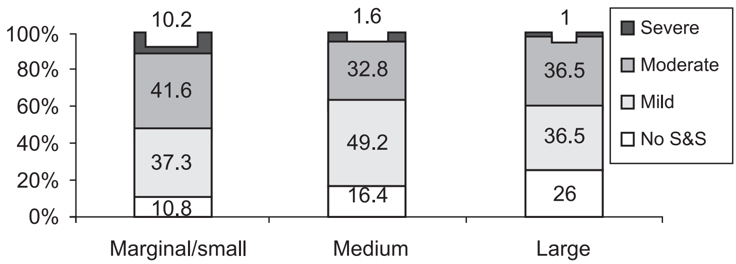


Figure 5.2 *Distribution of acute pesticide poisoning severity classes by landholding classes*

high association of the symptoms with the use of endosuifan, imidachloprid and acetamiprid but not with the use of any other pesticide is striking. No association between the three symptoms and the use of pyretroids, botanical and inorganic components was reported.

The frequency of spray-session illness events are significantly different depending on landholding status (chi square significant at $p < 0.0001$). The incidence of severe poisoning was 10 times higher among marginal farmers than larger landholding farmers (Figure 5.2). Of the marginal and small landholding farmers, 10.2 per cent suffered major effects. The distribution in Figure 5.3 shows that marginal and small farmers experienced more signs and symptoms than those who owned medium-sized and large farms. Average exposure time and pesticide toxicity were calculated for the sub-samples marginal, medium and large farmers, but the values did not explain this result. The level of formal education can partially explain the finding. Non-literate farmers experienced an average 4,8 #S&S and a severity class of 2,9 against respectively 2,4 and 2,2 for farmers educated to secondary school level. The values for farmers educated above secondary school level were remarkably lower (0,6 #S&S and 1,3 severity class), however, the sample was too small (4 farmers) to be considered representative.

The higher vulnerability of small and poor farmers could also be related to their general health conditions and to a cumulative effect of prolonged occupational exposure over the years. An important factor that could have played a role in diversifying exposure among groups is the application method, not considered in this study. Wealthier farmers are often in the position to afford safer equipment for applying pesticides. It worth noticing that 70 per cent of the asymptomatic events occurred among large and medium farmers. The higher incidence clearly reported calls for confirmation through an appropriate research design.

The village-wise analysis also showed a higher illness incidence among farmers in Darpalli than in the other two villages. Loss of consciousness and seizure had been recorded only among the poor community of this village. In the case of the two villages in Mahaboobnagar, the effects on the health of the reporting farmers were mild. The results of a separate ongoing analysis of the labour organization within the same households might provide additional information to cross-check

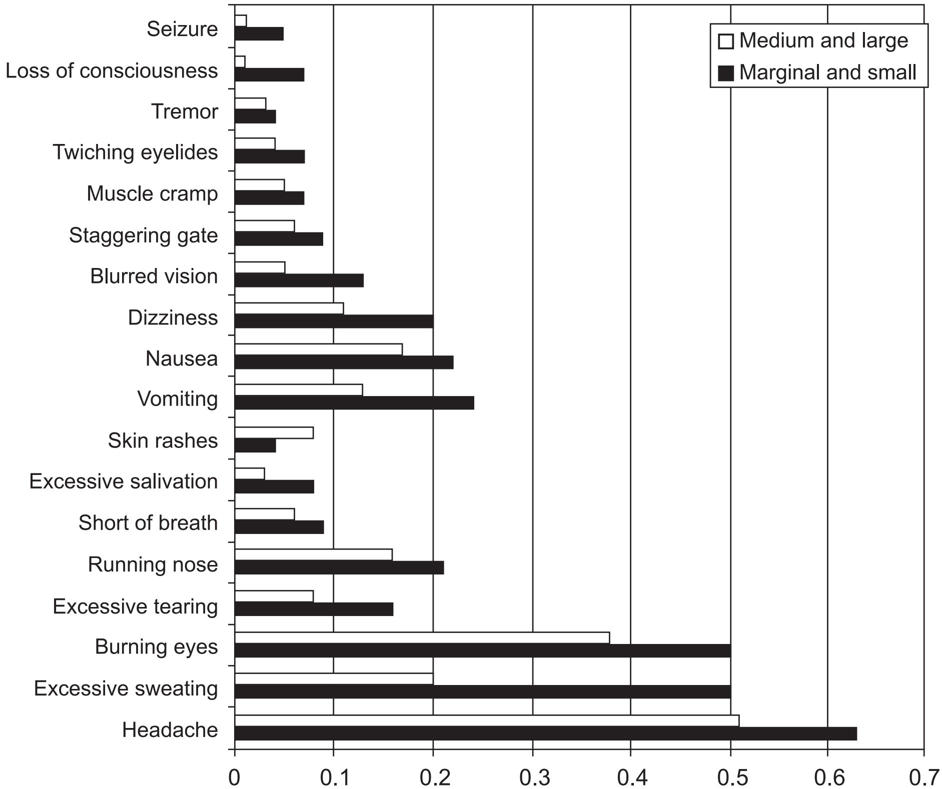


Figure 5.3 *Distribution of acute poisoning signs and symptoms by landholding classes*

individual exposure time to pesticides and explain some of the difference. A village effect might have been introduced in the reporting by the fact that each facilitator was operative in only one village.

The gender segregated analysis showed no significant differences in the distribution of signs and symptoms between men and women. Also, the severity class was not significantly correlated with the gender of the respondents. The health effects experienced by the women were comparable to the ones experienced by men. No significant correlation was found between severity class and age. However, the reader is reminded that children were not included in the surveillance. These results confirm the hypothesis that women are seriously exposed to pesticide contamination.

Severity class and total number of S&S (#S&S) versus exposure variables
Each exposure was described by five variables:

- *Pesticide toxicity*: toxicity of the formulated chemical product classified according to the WHO Hazard classes. Pesticides belonging to the WHO class 1a ('extremely hazardous') scored 1 point, class 1b ('highly hazardous') points 2, class II ('moderately hazardous') points 3 and class III ('slightly hazardous') points 4. Pesticides unlikely to present acute hazard in normal use (class U) were assigned with a score of 5 points.

- *Exposure time*: the duration in hours of the working session.
- *Volume*: the final volume of the spraying solution expressed in litres.
- *Operation*: the activity performed during the working session.
- *Profession*: The variable referred to whether the respondents were hired to apply pesticides in others' fields, in addition to their own.

The mean/median of the #S&S associated with the different categories of pesticide toxicity, the severity class and the exposure time is given Table 5.5. The distribution of the severity class by gender across operation performed (Table 5.6) showed that spraying and mixing were key exposure activities with a very similar incidence of severe poisoning. During mixing operations, the respondents prepared chemical solutions in rapid succession at close time intervals. Between mixing sessions, the respondents

Table 5.5 *Association between #S&S and severity classes, pesticide toxicity and exposure time*

Severity class	*#S&S Mean/ Median*	*P. Toxicity (WHO class)*	*#S&S Mean/Median*	*Exposure Time (hours)*	*#.S&S Mean/ Median*
No S&S	0/0	u	0.6/0	1–2	1.8/2
Mild	1.9/2	3	1.4/1	3–4	2.0/2
Moderate	4.0/4	2	2.7/2	5–6	2.4/2
Severe	8.4/8	Ib	3.0/2	7–8	4.8/5
		Ia	2.9/3	9 or 12	8.4/9

Table 5.6 *Distribution of the severity classes among operations by gender expressed in percentages and total number of events in brackets*

% (No.)		*Mixing*	*Mixing + fieldwork*	*Fieldwork*	*Spraying*	*Spraying + fieldwork*	*Total*
No S&S	Men	2(2)	0(0)	0(0)	1(1)	3(1)	1(4)
	Women	8(7)	0(0)	57(16)	19(26)	0(0)	15(49)
Mild	Men	4(3)	0(0)	0(0)	41(55)	0(0)	18(58)
	Women	49(42)	10(4)	43(12)	3(4)	19(7)	21(69)
Moderate	Men	1(1)	0(0)	0(0)	24(32)	60(21)	17(54)
	Women	31(27)	80(31)	0(0)	8(10)	5(2)	22(70)
Severe	Men	0(0)	0(0)	0(0)	4(6)	11(4)	3(10)
	Women	5(4)	10(4)	0(0)	0	3(1)	3(9)
Total		100(86)	100(39)	100(28)	100(134)	100(36)	(323)

Table 5.7 *Multiple regression of the severity class on socioecomonic and exposure variable*

Variable	*B Coefficient*	*Std. Error*	*Beta*	*t*	*Sig.*
Severity index					
Pesticide toxicity	.295	.035	.439	8.495	.000
Exposure time	.104	.021	.262	4.897	.000
Formal education	–.129	.063	–.128	–2.051	.041
Landholding	–1.11	.007	–.091	–1.499	.135
Profession	–.162	.120	–.076	–1.356	.176
	Adjusted R square = 0.292, F-value (df5, 275) = 24.1, P = 0.001				
#S&S					
Pesticide toxicity	.654	.106	.318	6.152	.000
Exposure time	.447	.065	.367	6.884	.000
Profession	–1.12	.367	–.171	–3.079	.002
Formal education	–.549	.193	–.177	–2.850	.005
Landholding	–3.87	.023	–.104	–1.705	.089
	Adjusted R square = 0.294, F-value (df5, 275) = 24.3, P = 0.001				

were present in the field. The same activities (mixing), when associated with fieldwork afterwards, led to a slight shift of the distribution towards a higher degree of severity. 'Mixing' and 'spraying' tasks had an average duration of 3.5 and 3.8 hours respectively. The same operations combined with fieldwork lasted 6.7 hours (mixing and field work) and 7 hours (spraying and fieldwork). Prolonged exposure led eventually to the development of more severe illness. Fieldwork alone did not cause any severe or moderate poisoning. This may be explained by the absence of direct contact with the concentrated chemical. To determine the contributions of individual factors, severity class and #S&S, were regressed (Table 5.7) on the five exposure variables, the three social variables (Gender, Age, Formal education) and three economic variables (Landholding, Income, Profession). The highest R^2 was found for the model that incorporated Education, Landholding, Profession, Exposure Time and Toxicity.

Participant observation of a pesticide spraying session

In order to corroborate the finding on women's exposure to pesticide, the first author observed some spray sessions in Darpalli village. Table 5.8 refers to a typical hour of work during which wife and husband were continuously present in the field. The pesticide mixture was prepared by the woman, without any sort of protective equipment. The concentrated product was mixed barehanded and every 7–9 minutes the tank was refilled, for a total of six refillings an hour. The session lasted three hours. Throughout the session the woman followed the man who was spraying the mixture. Repeated exposure of the two operators was evident. The average reporting session of the female respondents for 'mixing of pesticides' was

Table 5.8 *Time schedule of one hour spraying session (participant observation)*

Time	*Operator**	*Operation*	*Comments*
8.00 – 8.10	W	Preparation of spray solution	Bare hand
8.10 – 8.20	M	Spraying	Bare hand and foot
	W	Preparation of refilling	Legs and back wet
8.20 – 8.21	W	Refilling	Mixing with bare hand
8.22 – 8.29	M	Spraying	Strong smell of chemical spreads in the air
	W	Preparation of refilling	
8.30	W	Refilling	
8.30 – 8.40	M	Spraying	Both have to walk across the sprayed area to reach unsprayed areas. Contact with solution dripping from the plants
	W	Preparation of refilling	
8.41	W	Refilling	Rinsing of the chemical measuring container with bare hand
8.41 – 8.50	M	Spraying	Woman works in the field
	W	Preparation of refilling	
8.51	W	Refilling and moving to another field	
8.55 – 9.00	M	Spraying	
	W	Preparation of refilling	

* W = woman, M = man

likely to include 26–28 brief exposures to the concentrated products and a prolonged air exposure to the freshly applied mixture.

Medical assistance

Regardless of the seriousness of the illness, farmers sought medical advice in only 8 per cent of cases. Homemade treatments were taken in 70 per cent of the cases; no action was taken in the remaining cases. In rare cases, a few hours of extra rest (1.41 for women and 1.38 for men) were necessary before resuming the work. In 7 per cent of the cases, a full day's rest was recorded – a total of 23 sick days for the all participants during the four-month reporting period. This percentage is similar to the total number of severe cases reported (5.9 per cent).

This suggests that the use of sick days as an indicator might lead to an underestimation of the extent of pesticide poisoning.

Farmers' workshop

Farmers consolidated and discussed the results in a final workshop. A colour-based code, suitable for a non-literate population was used to score the forms following the same scoring procedure as described in this article. Participants attributed a final severity class to each form and analysed its frequency. The findings led to the farmers' realization of the serious health consequences associated with the irrational use of pesticides. The monitoring was conducted as part of the FAO Cotton IPM Programme to support the adoption of viable and socially acceptable alternatives to the pesticides.

Discussion

The study documented the serious consequences of the indiscriminate use of pesticides on farmers' health in India and specifically on women field helpers. The health surveys reviewed by Kishi in 2005 pointed out that the existing world data on poisoning refer mainly to young male subjects applying pesticides. There are also some examples that investigated the exposure of women who performed the same operations (Murphy et al, 1999; Kimani and Mwanthi, 1995; Trivelato and Wesseling, 1992). However, women in developing countries are prone to other ways of exposure because, through their supportive roles, they are often involved in the chemical application process (London et al, 2002). Few studies have mentioned this aspect and none have ever estimated the ill effects (Rother, 2000). The current survey addressed this information gap by focusing on the adverse effects developed by two target groups, women and marginal farmers, after they performed operations at risk of contamination.

The current self-monitoring has shown no differences between the degree of illness experienced by women and men. Whether this is related to the fact that women were reporting both on themselves and their husbands is not entirely clear. Nevertheless, women were reporting significant health effects. Typically female tasks, such as mixing concentrated chemical products and refilling spraying tanks, are key exposure activities, which have been proved to be as hazardous as the direct pesticide application itself.

Ten per cent of the spray sessions were associated with three or more neurotoxic/systemic signs and symptoms, which is the functional definition of acute poisoning used in Indonesia by Kishi et al (1995). The adverse effects on the central and the peripheral nervous systems were typical of poisoning caused by organophosphates (Keifer, 1997), these products were used in 47 per cent of the applications. Damage caused by cholinesterase-inhibitors with organophosphates can become permanent (McConnell and Magnotti, 1994; Miranda et al, 2002; Rosenstock et al, 1991; Wesseling et al, 2002). Although 6 per cent of the spray sessions were associated with serious neurotoxic effects, none sought medical care or were hospitalized. On the contrary, farmers rarely stop working for more than a day. This finding confirms the serious underestimation of statistics based on official medical records (Keifer, 1996; Murray, 1994).

Low-income marginal farmers are more often subjected to severe poisoning than landlords. Smallholders and landless people often apply pesticides throughout the season as waged. Repeated exposure, in addition to malnutrition and other diseases, might explain the higher vulnerability of these groups (WHO, 1990; Repetto and Baliga, 1997). Indeed, pesticide toxicity and exposure time were positively correlated to the extent to which symptoms were experienced in this survey, while formal education and landholding were negatively correlated to this measure of ill health. Yet, only 29 per cent of the variation in symptom severity could be explained by these factors.

However, more research is needed on factors contributing to the health of people exposed to pesticides, in particular high-risk groups that are rarely included in health surveillance on pesticides' effects (Moses, 1993; Zham and Blair, 1993).

The survey aimed primarily to raise farmers' awareness on the seriousness of the poisoning occurring in the villages. It also aimed to quantify the problem by direct farmers' reporting. The method has some limitations. Murphy's article (Murphy et al, 2002) includes a detailed strength and weakness analysis of the method. We have reported here only those aspects which are relevant to this survey. Since signs and symptoms of acute poisoning are non-specific, the health data generated can be taken only as estimates. Whether the women over- or underreported the true extent of the problem cannot be determined without biomarkers. A gender bias related to the difference in reporting methods between women and men could also have been introduced. Self-monitoring data would need to be backed up by clinical data and blood sample analyses, such as cholinesterase depressions. Another issue is that respondents belonging to the same village had close interactions. This may have introduced a systematic bias yielding homogeneity of reporting. Finally, the method cannot appreciate the chronic consequences of prolonged exposure to pesticides. Relevant in the case of women are the long-term effects on the reproductive system that can lead to abortions, still births, neonatal deaths and congenital defects (Restrepo, 1990; Taha and Gray, 1993; Zhang et al, 1992; Rojas et al, 2002). Nevertheless, a study conducted in India has shown that female cotton workers experienced the same long-term consequences of exposure to pesticides (Rupa et al, 1991). Our research concerned only adult respondents (above 18 years) and no age factor on the severity of the poisoning was found. However, the Pan American Health Organization estimated that between 10–20 per cent of all poisoning cases involve children. The cottonseed industry in India employs thousands of female children from 7 to 14 years old to manually cross-pollinate the plants. There is a need to investigate the impact on children exposed to pesticides. The survey covered one cotton season and therefore the number of records is limited. A second period of data collection is, however, scheduled for 2004 with the same respondents to estimate changes in farmers' health induced by the cotton IPM FFS.

The extent of pesticide poisoning among farmers and workers in developing countries is worrying (Kishi, 2005). In the extreme hot weather of the tropics, protective gear does not seem to be a viable solution to eliminate occupational risks. Farmers' education on the pesticide hazard alone has not achieved significant results. The solution seems to be in the replacement of pesticides with non- or less toxic alternatives. One example of such alternatives can be found in the Integrated Pest Management approach.

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Notes

1 Integrated Pest Management (IPM) is based on preserving natural enemies and growing healthy crops to control pests.
2 Farmer Field School (FFS) is an adult educational approach to empower farmers, developed in Indonesia in the early 1990s.
3 Developed by Keifer (1996) and adopted by Murphy et al (2002). The list is given in Table 5.2.

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Part II

Agroecology and Sustainability

6

The Properties of Agroecosystems

Gordon R. Conway

Introduction

Agroecosystems are ecological systems modified by human beings to produce food, fibre or other agricultural products. Like the ecological systems they replace, agroecosystems are often structurally and dynamically complex but their complexity arises primarily from the interaction between socioeconomic and ecological processes. Hitherto studies of agroecosystems have tended to concentrate on the flows and cycles of energy and materials (see reviews in Frissel, 1977; Loucks, 1977; Lowrance et al, 1984). While these have furnished valuable insights they have captured only a part of agroecosystem complexity and have had relatively little impact on the theory and practice of agricultural development. In this chapter I suggest that agroecosystems can be characterized by a limited set of dynamic properties that not only describe their essential behaviour, but can be used normatively as criteria of agroecosystem performance and hence can be employed in the design and evaluation of agricultural development projects, at all levels of intervention.

Agroecosystems as Systems

Although the concept of the ecosystem is long standing (Tansley, 1935), it is often difficult to identify and characterize ecosystems in nature. Their boundaries are frequently obscure and sometimes ecosystems appear to be no more than random clusterings of weakly interacting populations. Indeed, there has been some dispute as to whether natural ecosystems are true cybernetic systems, that is, have clearly defined goals and are steered towards realizing these goals by pervasive feedback control loops and communication networks (Engelberg and Boyarsky, 1979; McNaughton and Coughenour, 1981; Jordan, 1981; Knight and Swaney, 1981; Patten and Odum, 1981). Nevertheless, there can be little doubt that the transformation of ecosystem to agroecosystem produces well-defined systems of a cybernetic nature.

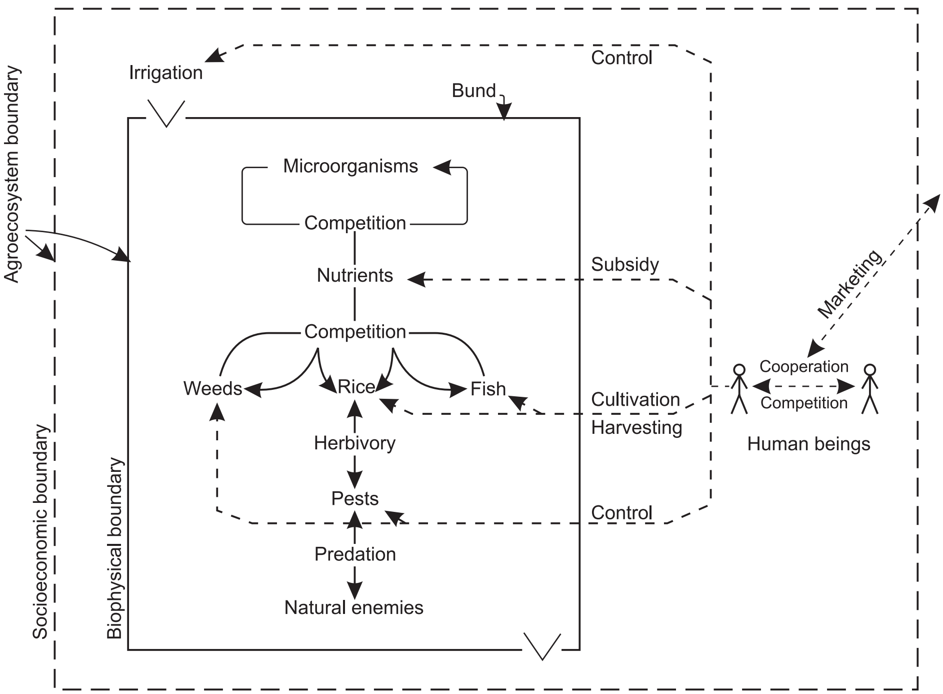


Figure 6.1 *The rice field as an agroecosystem*

In the transformation the great diversity of wildlife in the original natural system is reduced to a restricted assemblage of crops, pests and weeds (Figure 6.1). There is a strengthening of the biophysical boundary of the system, a bund is created around the rice field, for example, which makes the boundary less permeable. The basic ecological processes – competition, herbivory and predation – still remain, but these are now overlaid and regulated by the agricultural processes of cultivation, subsidy, control, harvesting and marketing. Recognizable system goals become apparent that are sought through human social and economic cooperation and competition. One consequence is that the system boundary acquires a socioeconomic dimension. It is this new complex agro–socio–economic–ecological system, bounded in several dimensions, that I call an agroecosystem. At least in cybernetic terms, an agroecosystem defined in this way is more similar to an individual organism than it is to a natural ecological system.

The most widely recognized agroecosystem is the crop field conceptualized in Figure 6.1, or the livestock paddock. But if agroecosystems are defined so as to include both ecological and socioeconomic components, then we can envisage a classical hierarchy of such systems (Figure 6.2). At the bottom of the hierarchy is the agroecosystem comprising the individual plant or animal, its immediate microenvironment, and the people who tend and harvest it. Examples where this exists as a recognizably distinct system are the lone fruit tree in a farmer's garden or the

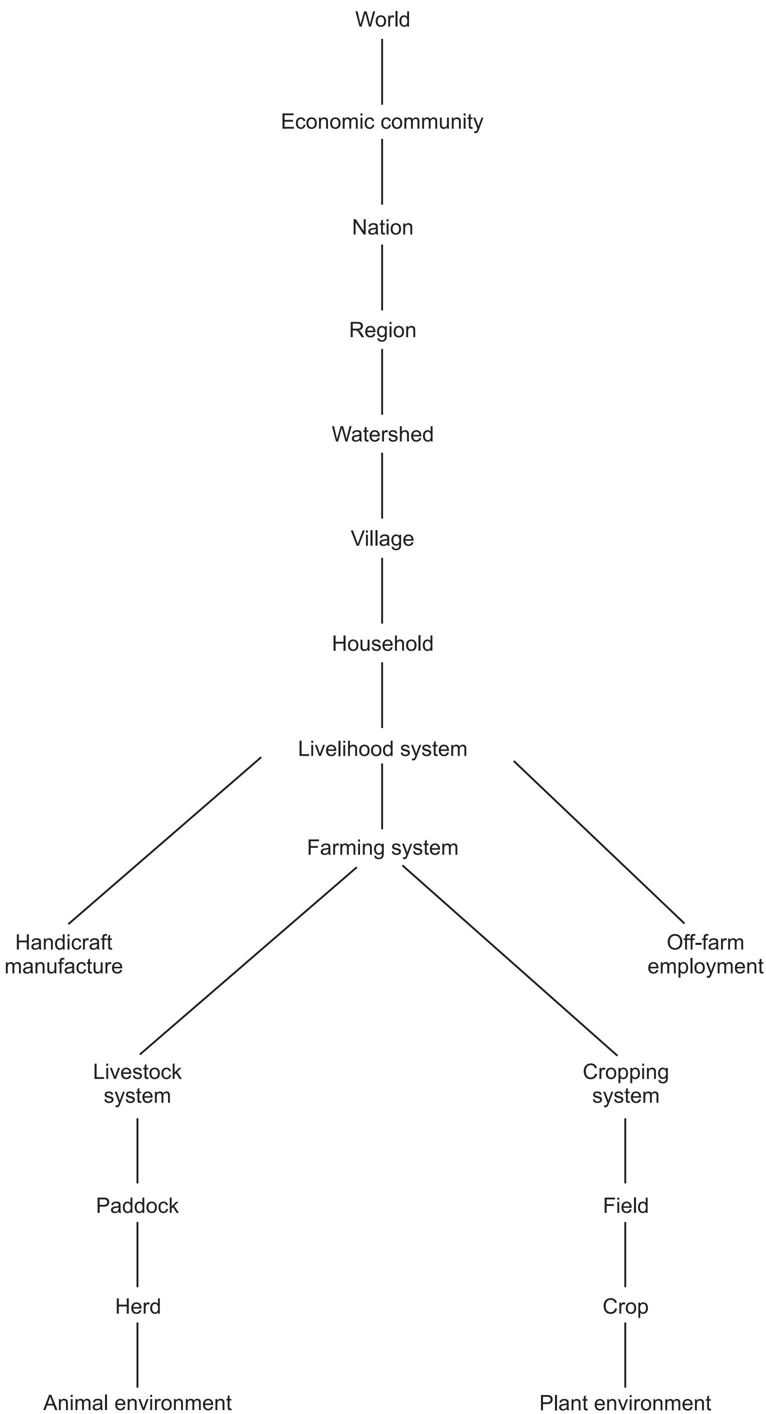


Figure 6.2 *The hierarchy of agroecosystems*

milk cow in a stall, but it is possible to think of the individual plant in a crop population or the animal in a herd in this way. The next level is the field or paddock and the hierarchy continues upwards in this way, each agroecosystem forming a component of the agroecosystem at the next level. Near the top is the national agroecosystem composed of regional agroecosystems linked by national markets, and above that the world agroecosystem consisting of national agroecosystems linked by international trade.

Systems theory holds that the behaviour of higher systems in such a hierarchy is not readily discovered simply from a study of lower systems, and vice versa (Simon, 1962; Whyte et al, 1969; Milsum, 1972; Checkland, 1981). This has important consequences not only for analysis but for agricultural policy and planning. It implies that agricultural development cannot be based solely, or largely, on genetic engineering, or macro-economic policy, or even on farming systems research. Each level in the agroecosystem hierarchy has to be analysed and developed both in its own right and in relation to the other levels above and below, and this totality of understanding used as the basis of development. To achieve this is a difficult task but is greatly helped by a common approach to analysis and, in particular, a set of well-defined common properties for each level in the hierarchy that can be related to each other, within and between levels.

Agroecosystem Properties

Individual organisms can be characterized by the basic properties of growth and reproduction, maintenance and survival (Table 6.1). In cybernetic terms the 'goal' of an organism is increased fitness and this is achieved through one of a variety of combinations of high and low values of these properties. The particular combination present in an organism can be regarded as its life history strategy (MacArthur and Wilson, 1967; Grime, 1979). For natural populations, communities and ecosystems it is possible to define a similar set of system properties, consisting of (1) productivity, (2) stability (constancy) and (3) resilience (as defined by Holling, 1973). In each case these refer to the numbers or biomass of individuals or species, or some combination of these measures. Unlike individual organisms, though,

Table 6.1 *The properties of ecological systems*

	Individual	*Population*	*Community*	*Ecosystem*	*Agroecosystem*
'Goal'	Fitness	(Fitness)	—	—	Social value
System properties	Growth Reproduction Maintenance Survival		Productivity Stability Resilience		Productivity Stability Sustainability Equitability

Source: Conway, 1982b.

there is no obvious 'goal' for a population, community or ecosystem and these properties are simply the outcomes of co-evolution.

However, for agroecosystems a clear goal, in the form of increased social value, is once again apparent. Social value, defined here in terms consistent with classical welfare economics (see, for example, Layard and Walters, 1978), is a function of the amounts of goods and services produced by the agroecosystem, their relationship to human needs (or happiness) and their allocation among the human population. Like fitness, it has a time dimension, humans seeking not only increased benefits in the immediate future but also a degree of security over the longer term. Social value thus has several measureable components: the present production, its likely level over a future time horizon and its distribution among the human population. Each agroecosystem, at each level in the hierarchy, has a social value and it also follows that one form of agroecosystem may have a greater social value than another (in much the same way that one organism is fitter than another) and hence may be selected for by a human population.

While welfare economics provides a good theoretical basis for defining social value, the concepts involved are of limited practical value. Production frontiers, utility and welfare functions are difficult, if not impossible, to measure. In practice, therefore, an assessment of an agroecosystem's performance has to be made not in terms of the theoretical goal but in relation to those key system properties that contribute most directly to realizing the goal. I have suggested there are four such primary agroecosystem properties – productivity, stability, sustainability and equitability (Conway, 1982a, 1982b). The first three approximately correspond to the properties of natural ecological systems; the principal distinction is that each is defined in terms of the valued output of the system and hence may be measured in both biological and socioeconomic units (Altieri and Anderson, 1986). The fourth property, equitability, has no direct counterpart in natural ecological systems.

Productivity

Productivity is defined here as the output of valued product per unit of resource input. Common measures of productivity are yield or income per hectare, or total production of goods and services per household or nation, but a large number of different measures are possible, depending on the nature of the product and of the resources being considered. Yield may be in terms of kilograms of grain, tubers, leaves or of meat or fish or any other consumable or marketable product. Alternatively, it may be converted to value in calories, proteins or vitamins or to its monetary value at the market. Frequently, the valued product may not be yield in conventional agricultural terms. It may be employment generation, or an item of amenity or aesthetic value or one of a wide range of products that contribute, in ways that are difficult to measure, to social, psychological and spiritual well-being (Chambers, 1986).

The three basic resource inputs are land, labour and capital. Strictly speaking, energy is subsumed under land (solar energy), labour (human energy) and capital (fossil fuel energy). Similarly, technological inputs, such as fertilizers and pesticides, are components of capital, but both energy and technology can be treated, for many purposes, as separate inputs.

Each possible combination of output and input can be regarded also as measures of efficiency of production when two or more agroecosystems are compared (NAS, 1975; Spedding, 1979). Assessments may be made of productivity at different levels in the hierarchy of agroecosystems, of the field, farm, village, watershed, region or nation. Also comparisons may be made between agroecosystems of different types (e.g. between a cornfield and a cottonfield, or a lowland and an upland village). Over time productivity may rise, fall or remain static.

Stability

Stability may be defined as the constancy of productivity in the face of small disturbing forces arising from the normal fluctuations and cycles in the surrounding environment. Included in the environment are those physical, biological, social and economic variables that lie outside the agroecosystem under consideration. The fluctuations, for example, may be in the climate or in the market demand for agricultural products. Productivity may be defined in any of the ways described above and its stability measured by, say, the coefficient of variation in productivity, determined from a time series of productivity measurements. Since productivity may be level, rising or falling, stability will refer to the variability about a trend.

Sustainability

Sustainability is defined as the ability of an agroecosystem to maintain productivity when subject to a major disturbing force. The actual or potential disturbance may be caused by an intensive stress, where stress is defined as a frequent, sometimes continuous, relatively small and predictable disturbing force which has a large cumulative effect. Salinity, toxicity, erosion, indebtedness or declining market demand are examples of such forces. Alternatively, the disturbance may be caused by a shock, defined here as an infrequent, relatively large and unpredictable disturbing force which has the potential of creating an immediate, large disturbance or perturbation. Examples of shocks include a rare drought or flood, or a new pest or the sudden rise in an input price, such as that of oil in the mid-1970s.

Following a stress or shock the productivity of the agroecosystem may be unaffected, or may fall and then return to the previous level or trend, or settle to a new lower, or sometimes higher, level or may disappear altogether. Various measures of sustainability are available: they include the inertia (resistance), elasticity, amplitude, hysteresis and malleability of the agroecosystem in response to a disturbing force (Orians, 1975; Westman, 1978). Sustainability thus determines the persistence or durability of an agroecosystem's productivity under known or possible conditions. It is a function of the intrinsic characteristics of the agroecosystem, of the nature and strength of the stresses and shocks to which it is subject, and of the human inputs that may be introduced to counter these stresses and shocks.

A ubiquitous input is the subsidy, often in the form of a fertilizer application, intended to counter the stress of repeated harvesting. Sustainability is maintained only by renewed fertilizer application. Another common form of input is a control agent; for example, a pesticide to counter pest or disease attack. Again, sustainability may necessitate repeated pesticide applications, but an alternative strategy may be the introduction of a biological control agent, such as a parasitic wasp, which may so permanently alter the intrinsic sustainability characteristics of the agroecosystem as to obviate the need for further intervention. In some situations inputs may become part of the problem because, directly or indirectly, they generate stresses and shocks. Frequent pesticide applications, for example, may elicit pesticide resistance and hence growing pest attack. The number of applications may have to be increased to sustain productivity, but in the end productivity may still collapse (Figure 6.3).

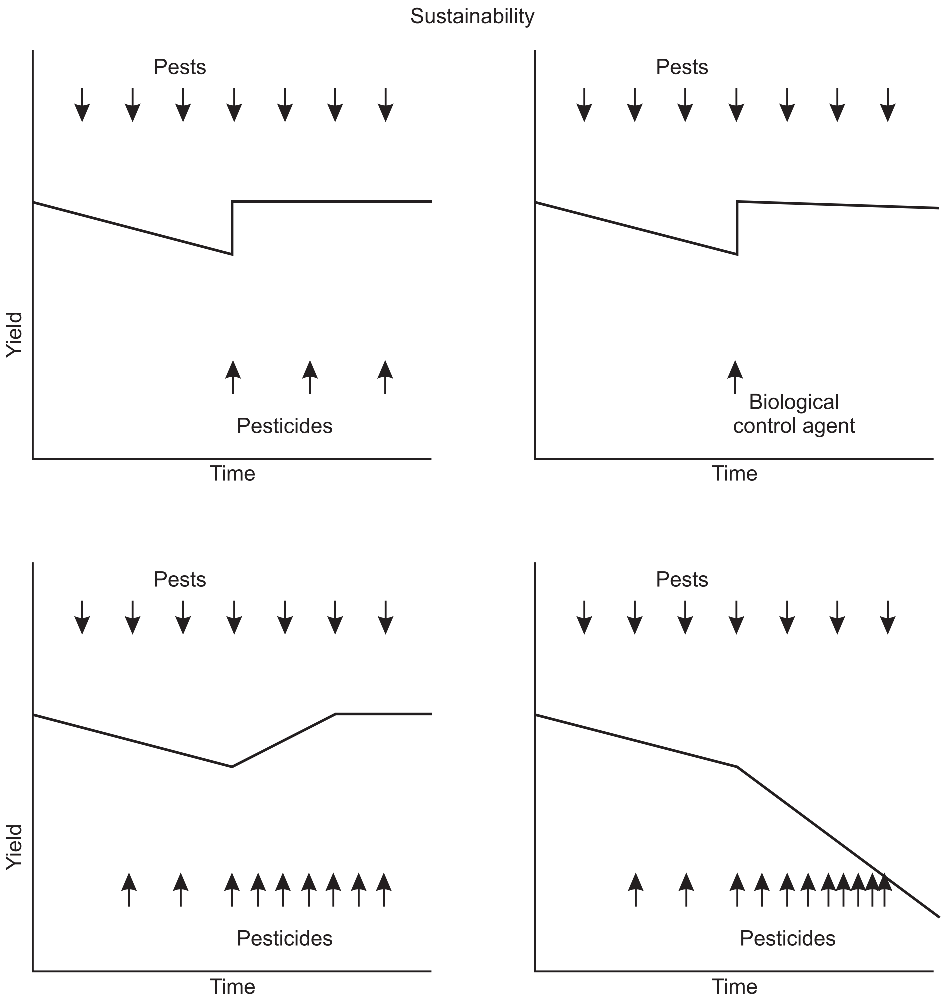


Figure 6.3 *The effect of pest control on sustainability*

Equitability

Equitability is defined as the evenness of distribution of the productivity of the agroecosystem among the human beneficiaries. Once again, the productivity may be measured in many ways, but, commonly, equitability will refer to the distribution of the total production of goods and services of the agroecosystem under consideration, i.e. the field, farm, village or nation. The human beneficiaries may be the farm household, or the members of a village or a national population.

Equitability may be measured by a Lorenz curve, Gini coefficient or some other related index (Lorenz, 1905; Gini, 1912; Kuznets, 1955; Theil, 1967; Atkinson, 1970, 1975; Gastwirth, 1972; Sen, 1973, 1976; Fields, 1980; Kakwani, 1980). In practice, though, it is difficult to define equitability in a purely positive sense, the measures available reflecting different value judgements. Equitability is thus often the evenness of distribution of productivity among the human beneficiaries according to need.

Factors Affecting System Properties

Although the four properties, described above, are the key properties in determining the social value of an agroecosystem there are a large number of other ways that can be used to characterize an agroecosystem. Examples include energy and materials conservation, diversity, autonomy, market penetration and some measure of cultural acceptability. Each of these, however, can be shown to contribute to social value through one or more of the four primary properties, in much the same way as birth rate contributes to the productivity of a population or photosynthesis to the growth of a plant. Thus materials conservation can contribute to productivity but also has a major effect on stability and sustainability; diversity contributes to all four primary properties, although in rather complex ways; and cultural acceptability is an important component of sustainability and equitability.

An early step in the analysis of a given agroecosystem is to identify the important factors and processes that affect the primary system properties. Table 6.2 shows one such list for the high altitude villages in the Karakoram mountains of northern Pakistan, produced during an Agroecosystem Analysis workshop (Conway et al, 1985).

Agricultural Development

The four properties are linked with each other, both within an agroecosystem and between agroecosystems at different levels in the hierarchy. However, the linkages are complex and frequently negative in effect. If we now regard the properties as

Table 6.2 *Key variables and processes affecting the system properties of villages in northern areas of Pakistan (after Conway et al, 1985)*

Positive	*Negative*
Productivity	
Construction of Karakoram Highway	Shortage of cultivable land
Development of new land	Shortage of water
Inorganic fertilizers	Weeds, pests and diseases
New wheat and fruit varieties	Seasonal labour shortage
Introduction of seed potato cultivation	
New credit loan system	
Stability	
Integration of crops and livestock	Crop pests and diseases
Cooperative marketing	Livestock diseases
Improvement of irrigation channels	Temperature fluctuations
Sustainability	
Farmyard manure	Glacier movement
Crop rotation (wheat, potatoes)	Mudflows, avalanches
Training of village livestock specialists	Earthquakes
	River bank erosion
	Virus of seed potatoes
	Overuse of pesticides
Equitability	
Traditional cooperation	Sale of land
Creation of Village Organizations	Education
Rotation of pasturing	Emigrant labour
Development of new land	

normative indicators of performance, rather than neutral descriptors, then agricultural development will involve significant trade-offs between them. For example, a large-scale irrigation project may achieve greater overall productivity yet be at the expense of sustainability and equitability. Similarly, too much emphasis on equitability may inhibit productivity. Within a farm, high stability and sustainability may depend on a complementary diversity of crop fields and livestock systems, each of which produces less than its maximal potential and is more variable in yield and individually less sustainable than is the total farm. A similar situation can occur between the nation and its agricultural regions.

The trade-offs can be seen clearly in the history of agriculture. Each combination of properties can be thought of as an agroecosystem strategy, successive phases of agricultural development reflecting different priorities and hence strategies. The following selected examples from agricultural history are intended to illustrate these points.

The origins of agriculture

Much is known about the where, when, and, to some extent, how, of the origins of agriculture, but there is still considerable controversy over the why (Reed, 1969; Higgs and Jarman, 1972; Bender, 1975; Clark, 1976; Cohen, 1977; Orme, 1977). It is generally accepted that agriculture, by which I mean the cultivation or husbandry of domesticated plants and animals, began independently in at least six widely dispersed regions of the world – the Fertile Crescent (*c.* 9500 BP), Mesoamerica (*c.* 7000 BP), South America (*c.* 6000 BP), South-West China (*c.* 7000 BP) and South-East Asia (*c.* 6000 BP) and Northern India (*c.* 8500 BP). The difficult question to answer is why such a revolutionary event should have occurred in such widely dispersed places, at roughly the same time.

A number of cultural explanations have been proffered (Braidwood and Howe, 1960; Braidwood and Willey, 1962; Ucko and Dimbleby, 1969) as have hypotheses which suggest agriculture was a response to the pressures of an adverse period of climate (Childe, 1936) or of population growth (Cohen, 1977). In each case the writers have assumed, explicitly or implicitly, that the crucial advantage of agriculture over hunting and gathering was its greater productivity. However, a number of arguments suggest that, at least initially, it may have been the relative stability of agriculture that was more important.

Hunter-gathering can be highly productive: the Pacific Coast Indians of North America, for example, were able to support themselves at much higher densities than agricultural groups elsewhere in the continent (Kroeber, 1939; Baumhoff, 1963). But the basic hunter-gatherer foods – migratory salmon, acorns, wild cereals – usually show dramatic year-to-year fluctuations, Moreover, many of the centres of origin exhibit highly seasonal and variable climates and are characterized by mosaics of 'good' and 'bad' food-producing environments. Significantly, the archaeological evidence reveals that, at least in the Fertile Crescent and Mesoamerica, agriculture remained a minor contribution to food supply for long after its inception, 4000 years in the case of Mesoamerica (Flannery, 1969; Bray, 1977). As Boserup (1965) suggests, agriculture may have begun by small daughter bands migrating, in response to local population pressure, into areas more marginal for the wild staple crops. Here the yields were likely to have been even less stable and cultivation and domestication may have arisen as a response to this pronounced instability.

Once, however, agriculture began to spread into other regions of the world, particularly to temperate climates, its superiority in productivity terms was clearly apparent and it was rapidly adopted (Clark, 1965; Ammerman and Cavalli-Sforza, 1971). There were consequences, though, for sustainability and equitability. Early irrigation bought stresses from rising water tables and salinity; grain yields in Sumer dropped from 1850kg/ha to 650kg/ha between 2400 BC and 1700 BC (Jacobsen and Adams, 1958) and there is archaeological evidence of erosion turning arable to wasteland (Dennell and Webley, 1975). Equitability, too, may have declined wherever agriculture became associated with family ownership of land.

Manorial agriculture

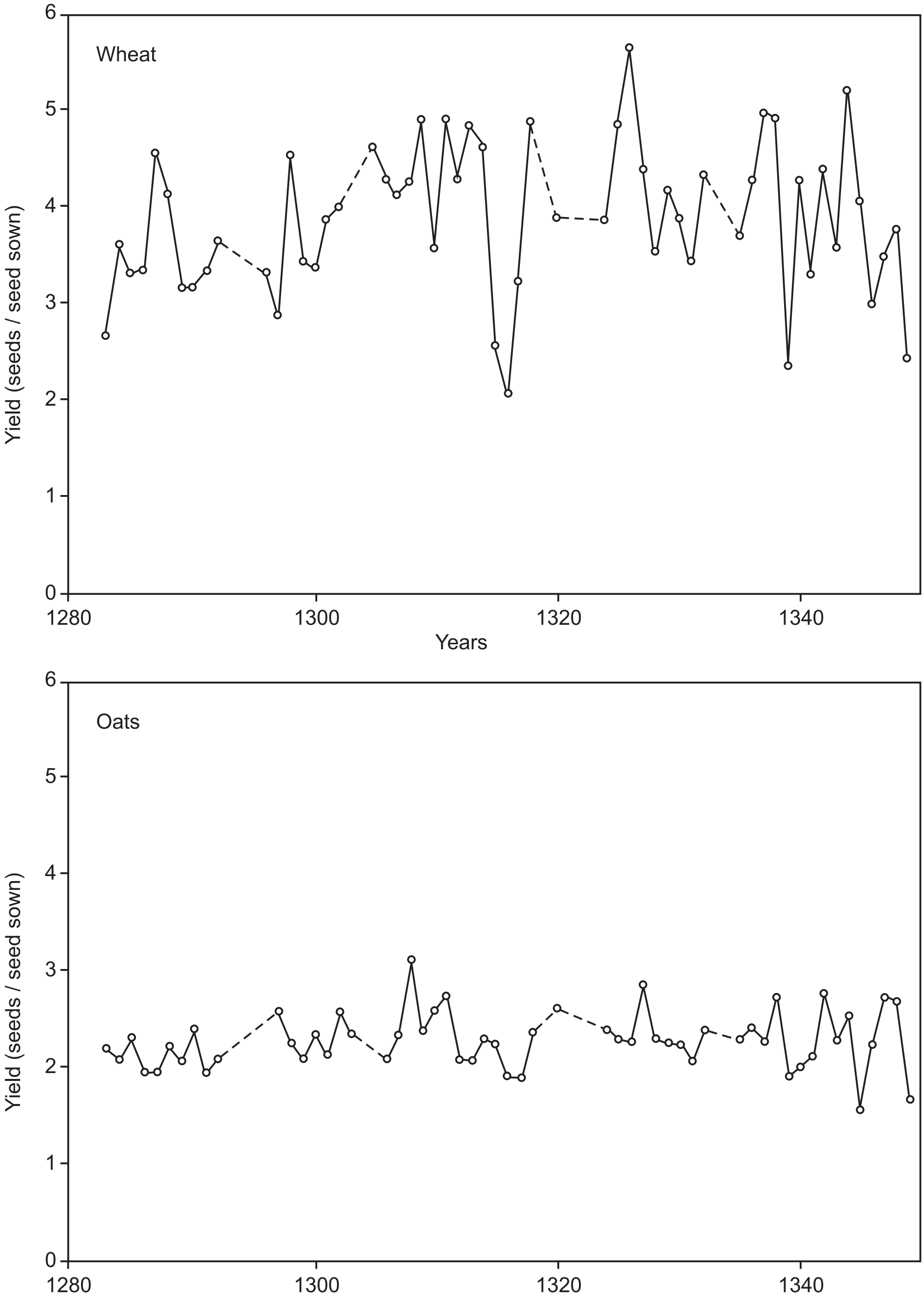
One of the longest lasting agroecosystems in history was the manorial system, introduced into Britain by the Anglo-Saxons in the 7th century and persisting until the 14th century (Aston, 1981). Although considerable differences arose from place to place, the essential features of the system remained remarkably constant (Gras, 1925; Ernle, 1961; Stenton, 1965; Baker, 1983). The ecological basis of its sustainability was the three-course rotation of the open fields (two course on poorer land, Gray, 1915), that followed a sequence of winter wheat or rye, spring sown oats, barley, beans or other legumes and then a ploughed fallow. This helped prevent the build up of pests, diseases and weeds, while marling and a limited use of manure ensured a good soil structure. Sustainability was promoted also by the strict control enforced by the village council over cultivation dates, stocking rates and the allocation of land (Ault, 1965).

Despite the hierarchy of the feudal system there appears to have been a relatively high degree of equitability, at least among the landholding peasants. The individual strips in the open fields were allocated so that each family received a fair share of good and bad land while grazing rights on the open fields and on the commons were equally shared.

Productivity, though, was low. Cereal yields were little changed from those of the wild harvests several thousand years before in the Fertile Crescent (Harlan, 1967). Returns to seed were only three- to six-fold. Oats and barley gave the highest yields per acre but the return on the seed sown was lower than that of wheat. A good idea of the stability of production can be obtained from a remarkable set of manorial records (Figure 6.4). Oats were the most stable crop and this may explain why it was the mainstay of the peasant's food. Note that in the very wet years of 1315–1317 wheat yields were greatly reduced while oats were little affected. Pretty (1981) has analysed the responses of these crops to disturbance and shown that oat yields recovered more quickly than wheat following a bad year. Oats were also more stable in terms of price.

Eventually, the manorial system did break down, partly under the pressure of growing population. By the early 14th century productivity was falling, to the extent that some land was being abandoned (Titow, 1969). Other contributing factors were the growth of a monetary economy replacing that based on allegiances and barter, and the pressure for social change. The process was also accelerated by the outbreak of plague, known as the Black Death, which entered Britain in 1348.

The collapse of the manorial system and the enclosure of the open fields to produce individual estates and farms caused great hardship among the peasantry but increased productivity per unit of land and labour. Moreover, it made possible the application of the 18th century scientific revolution. associated with the names of Townshend, Coke, Bakewell, Tull and others, which managed to combine high productivity with sustainability based on rotations incorporating roots and legumes and intensive recycling of crop and livestock waste (Plumb, 1952; Kerridge, 1955; Parker, 1955; Riches, 1967; Chorley, 1981).



Source: Titow, 1972.

Figure 6.4 *Cereal yields for 14 manors under the jurisdiction of the Bishop of Winchester, 1283–1349*

Modern western agriculture

The dominant factor in western agriculture during the latter part of the 20th century has been protectionism. In the UK, for example, the experiences of the great agricultural depressions, notably at the end of the 19th century and in the 1930s, led to the passing of the Agricultural Act of 1947 which introduced a wide range of subsidies and guaranteed prices for most major agricultural products. Subsequently, the creation of the Common Agricultural Policy (CAP) in 1957 under the European Economic Commission (EEC) instituted the right to comparability of income between workers in the agricultural and industrial sectors throughout most western European countries and ensured this through a complicated system of external tariff walls, levies, intervention prices and export refunds. European farmers have been protected from the fluctuations in world markets and productivity has risen dramatically. Over the past three decades nitrogen fertilizer applications in the UK have risen from 200,000 to over 1,400,000 tons, and cereal yields from an average 3 tons/ha to 6 tons/ha while the number of farm workers has declined from 800,000 to under 400,000 (Conway, 1984). Large EEC surpluses, notably of beef, milk, cereals, sugar and wine, have been created.

Over the same period land prices have risen and farmers' incomes in Britain doubled, improving in relation to manual and farm workers, whereas other comparable occupations have declined (Bowers and Cheshire, 1983). Although small and marginal farmers have benefited from the subsidies, the bigger, richer and more specialized farmers have benefited more. For the UK as a whole, the CAP system of price guarantees is effectively borne by the public as consumers, rather than as taxpayers, and hence the impact on income distribution has been regressive.

The increased agricultural productivity has also been at the expense of the amenity, recreation and conservation values of the countryside. There have been recent, large-scale losses of ancient woodlands, chalk grasslands, herb rich meadows, heaths, hedgerows, lakes, fens and mires (Nature Conservancy Council, 1984). Moreover, this has occurred at a time when use of the countryside for walking, angling, camping, horseriding and natural history pursuits involves millions of the public and is rising dramatically (Conway, 1984). Pollution from agriculture is also increasing. Water pollution incidents arising from livestock or silage effluent have doubled since 1979 in the UK (WAA, 1986), while in several parts of the country nitrate levels in drinking water supplies are close to new European limits (Young et al, 1976; Oakes, 1981; Wilkinson and Greene, 1982). In these cases the costs of pollution caused by agriculture are borne by the public rather than by the farming community.

How sustainable is this high level of production remains open to debate. There is some evidence for increased soil erosion (Morgan, 1985a, 1985b) and concern is being expressed over soil quality and the danger of growing pesticide resistance. More important, however, is the cost of subsidizing production at the present levels. Western European governments have already instituted milk quotas and are examining the various consequences of moving towards a lower input/lower output agriculture.

In North America protection generally has been at a somewhat lower level. Indeed, part of the cause of current high levels of bankruptcies among US farmers is lack of protection from fluctuating world prices. Average yields per hectare for cereals are generally lower than in Europe (2 tons/ha is the national average for wheat in the US compared to 6 tons/ha in the UK). Nevertheless, there have been dramatic increases in productivity, particularly in returns to labour, resulting from intensive mechanization and inputs of agrochemicals. But soil erosion is now a major threat and in some regions sustainability is being jeopardized by exhaustion of irrigation water supplies (Crosson and Brubaker, 1982; Larson et al, 1983; Brown and Wolf, 1984; Postel, 1984, 1985; Helms and Flader, 1985).

The Green Revolution in Indonesia

My final example concerns the transformation that has occurred over the last three decades in the agriculture of many of the less developed countries (LDCs). Agricultural scientists tend to dislike the phrase 'Green Revolution' with its journalistic overtones. But the exploitation of the new cereal varieties, bred by the International Agricultural Research Centres, with their high pay-off genetic characteristics of resistance to lodging, insensitivity to photoperiod and early maturation, coupled with the organization and distribution of high pay-off inputs such as fertilizers, water-regulation and pesticides, and targeted on the best favoured agroclimatic regions and the most progressive farmers, has all the hallmarks of a successful technological revolution.

The benefits in terms of productivity have been very great. Over the past two decades food production in Asia has grown overall by 15 per cent per capita and many countries in the region are close to cereal grain self-sufficiency. Indonesia's rice production has grown from under 14 million tons in the late 1960s to over 25 million tons in 1984 and the country now has a small surplus.

This dramatic increase in LDC productivity has been accompanied, however, by numerous problems, ranging from pest and disease outbreaks to loss of communal self-help arrangements (Frankel, 1971; Cleaver, 1972; McNeil, 1972; Nickel, 1973; Collier et al, 1974; Griffin, 1974; Hauri, 1974; Palmer, 1976; Collier, 1977; IRRI, 1979, 1980, 1981; Murdoch, 1980; Pearse, 1980; Hayami, 1981; Maunder and Ohkawa, 1983; KEPAS, 1984). In Indonesia the rice production strategy received a severe setback in the mid-1970s due to recurring and devastating outbreaks of brown planthopper (*Nilaparvata lugens*) (Conway and McCauley, 1983). A switch to a new variety, IR36, was followed by a serious attack of tungro disease, necessitating yet new varietal introductions. Large-scale plantings of uniform crop varieties are intrinsically prone to pest and disease build up, particularly where planting is asynchronous (Loevinsohn, 1984). Sustainability in these circumstances is dependent on the crop breeders always staying one step ahead.

Indonesia's rice strategy has also had dramatic effects on labour use and equitability (Conway and McCauley, 1983). Prior to the introduction of the new rice varieties the harvest was open to all members of the village, the poor and landless being able to retain a fixed proportion of the rice they harvested. But the growing number of landless has made it difficult for farmers to control the harvesting so that now it is carried out by contract groups (Collier et al, 1973). The traditional hand-milling of rice by the women of the village, who received grain in lieu of money payment, has also disappeared, replaced by mechanical hulling (Timmer, 1973). And, despite self-sufficiency, malnutrition persists, even in some of the most agriculturally productive villages.

The final question is whether the national effort is sustainable. Indonesia's oil and gas boom is now over and the budget surpluses which subsidized the agricultural revolution are gone. Inevitably, there will be bad years due to pest and disease outbreaks or poor rainfall. These will place a heavy demand on central resources and agencies who will have to deliver what in the past was the function of communal self-help arrangements and the evolved diversity of traditional agroecosystems.

Agroecosystem Analysis and Development (AAD)

Until recently the various agricultural regions of the world differed from each other in the various weights accorded the agroecosystem properties. In the 1930s, for example, conservation agriculture was being practised in Britain while the Dust Bowl was being created in the midwest of the US. But today agriculture is facing a common worldwide challenge. The pursuit of high productivity in both the developed and less developed countries has brought with it declines in sustainability and equitability that increasingly are being regarded as undesirable. Our present priority is for policy research, practical analytical tools and development packages aimed at increasing agricultural sustainability and rectifying undesirable inequities.

One step in this direction has been the development of Agroecosystem Analysis (Conway, 1985a, 1986). This is a technique of multidisciplinary analysis which may be used at any level in the agroecosystem hierarchy, and generates a set of research and development priorities that explicitly take account of the trade-offs between the system properties. The technique has been used so far to determine research priorities for university and government teams (Gypmantasiri et al, 1980; KKU-Ford, 1982a, 1982b; KEPAS, 1985a, 1985b), development priorities in project design (Limpinuntana and Patanothai, 1984; Conway et al, 1985) and to evaluate project performance and recommend corrective actions (Conway and Sajise, 1986).

A second component of AAD (Conway, 1985b) is the further development and refinement of a variety of packages that promise high productivity without loss of sustainability or equitability. Such packages include Integrated Pest Management, multiple cropping, crop livestock polyculture, agroforestry, communal resource use, communal water control, social forestry and integrated handcraft manufacture.

The next step is to devise ways of incorporating these concepts, tools and packages into formal policy and project design in such a way that the trade-offs are made explicit and accounted for in as rigorous a manner as is currently customary for conventional economic analysis.

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7

Interdependent Social-Ecological Systems and Adaptive Governance for Ecosystem Services

Carl Folke, Johan Colding, Per Olsson and Thomas Hahn

Introduction

The pre-analytic vision of this chapter is that human societies and globally interconnected economies are parts of the dynamics of the biosphere, embedded in its processes and ultimately dependent on the capacity of the environment to sustain societal development with essential ecosystem services and support (Odum, 1989; Millennium Ecosystem Assessment, 2005). Throughout history humans have shaped nature and nature has shaped the development of human society (Turner et al, 1990; Redman, 1999). The human dimension has expanded and intensified and become globally interconnected, through technology, capital markets and systems of governance with decisions in one place influencing people and ecosystems elsewhere (Holling, 1994). Reduced temporal variability of renewable resource flows in some parts of the world has resulted in increased spatial dependence on other areas on earth, reflected in for example widespread ecosystem support to urban areas (Folke et al, 1997). Humanity has become a major force in structuring ecosystem dynamics from local scales to the biosphere as a whole (Steffen et al, 2004).

In this context it becomes clear that patterns of production, consumption and well-being develop not only from economic and social relations within and between regions, but in order to be sustained they also depend on the capacity of ecosystems throughout the world to support societal development (Arrow et al, 1995). Social conditions, health, culture, democracy and matters of security, survival and the environment are interwoven in a grand panorama of regional and worldwide dependency.

Sometimes change is gradual or incremental. During these periods of steady progress, things move forward in roughly continuous and predictable ways. At other times, change is abrupt, disorganizing or turbulent. During such periods, experience is often insufficient for understanding, consequences of actions are ambiguous, and the future of system dynamics often uncertain (Gunderson and Holling, 2002). Evidence points to a situation where periods of abrupt change are likely to increase in frequency and magnitude (Steffen et al, 2004), which poses new fundamental challenges for science, management, policy and governance.

Theories, models and policies for resource and environmental management have to a large extent been developed for gradual or incremental change situations focusing on a unique state with assumptions of linear dynamics and generally disregarding interactions across scales. Recent research has revealed that the implementation of such theory and policy tend to invest in controlling a few selected ecosystem processes, at the expense of key ecological functions, in the urge to fulfil economic or social goals (e.g. Gunderson et al, 1995; Holling and Meffe, 1996; Allison and Hobbs, 2004). This behavioural pattern causes loss of resilience (capacity to buffer change and continue to develop) of desired states (Holling, 1973; Folke, 2006a). Loss of resilience results in vulnerable systems. Historical loss of resilience has put whole regions and cultures into vulnerable states with constrained options for development (Kasperson et al, 1995; Redman, 1999; Schröter et al, 2005). Vulnerable systems subject to change may easily shift from one state (stability domain, basin of attraction) into another (Walker and Meyers, 2004). When such shifts occur the common focus tends to be on the event that revealed the shift and not on the variables, processes and trajectories that caused loss of resilience prior to the event.

To what extent are human societies adapting their capacity for learning and foresight to deal with this new global and challenging situation? We agree with the findings of the Millennium Ecosystem Assessment that the societal capacities to manage the Earth's ecosystems are evolving more slowly than humanity's [over]use of the same systems. Conventional resource models, based on single resources and linear dynamics, are of limited use for the purpose of navigating society towards sustainability.

The perspective presented here emphasizes the following features:

1 society and nature represent truly *interdependent social-ecological systems*;
2 social-ecological systems are *complex adaptive systems*;
3 *cross scale and dynamic interactions* represent new challenges for governance and management in relation to interdependent social-ecological systems and ecosystem services.

Research for sustainability increasingly addresses the intricate feedbacks of social-ecological systems, their complex dynamics and how they play out across spatial and temporal scales. A deeper understanding of coupled systems undergoing change is essential in this context. The implications for current management and policy are challenging.

Here, we provide a brief overview of the three features and then turn to a discussion of systems of adaptive governance (Dietz et al, 2003, Folke et al, 2005) that allow for responding to, adapting to and shaping environmental change. We highlight some features of such governance systems by focusing on management practices of human groups involved with ecosystems and social mechanisms behind such management, including social taboos, social networks, bridging organizations, leadership and actor groups. Societies face the challenge of dealing with unpredictability, uncertainty and change and how to build resilience to periods of abrupt change and allow for transformations into more desirable social-ecological pathways.

The Three Features

Interdependent social-ecological systems

In our view, there are neither natural or pristine systems without people nor social systems without nature (Folke, 2006b). Social and ecological systems are not just linked but truly interconnected and co-evolving across spatial and temporal scales (Berkes and Folke, 1992; Norgaard, 1994). We refer to them as *social-ecological systems* (Berkes and Folke, 1998) emphasizing the humans-in-the-environment perspective (Berkes et al, 2003). It is close to impossible to truly understand ecosystem dynamics and their ability to generate services without accounting for the human dimension. Focusing on the ecological side only, as a basis for decision making for sustainability, simplifies reality so much that the result is distortions and leads to incomplete and narrow conclusions. For example, an observed shift in a lake from a desired to a degraded state may indicate that the lake has lost resilience, but if there is capacity in the social system to respond to change and restore the lake, the social-ecological system is still resilient (Carpenter and Brock, 2004; Bodin and Norberg, 2005).

The same is true for social sustainability. Despite a vast literature on the social dimension of resource and environmental management, studies have predominantly focused on investigating processes within the social domain only, treating the ecosystem largely as a given, an external 'black box', assuming that if the social system performs adaptively or is well organized institutionally, it will also manage resources and ecosystems in a sustainable fashion. A human society may show great ability to cope with change and adapt if analysed only through the social dimension lens (Huitric, 2005). But such an adaptation may be at the expense of changes in the capacity of ecosystems to sustain the adaptation, and may generate traps and breakpoints in social-ecological systems (Allison and Hobbs, 2004).

There has been substantial progress in understanding the social dimension of ecosystem management, including organizational and institutional flexibility for dealing with uncertainty and change (e.g. Lee, 1993; Grumbine, 1994; Westley, 1995; Berkes and Folke, 1998; Danter et al, 2000; Gunderson and Holling, 2002; Berkes et al, 2003; Dietz et al, 2003; Anderies et al, 2004; Armitage, 2005; Ostrom, 2005) and social capital and conflict (e.g. Ostrom and Ahn, 2003; Adger, 2003;

Table 7.1 *Social-ecological practices and mechanisms of local communities and traditional societies in the case studies of the Berkes and Folke (1998)* Linking Social and Ecological Systems *volume*

1 Management practices based on ecological knowledge

- A Practices found in conventional resource management and in local and traditional societies
  - Monitoring resource abundance and change in ecosystems
  - Total protection of certain species
  - Protection of vulnerable life history stages
  - Protection of specific habitats
  - Temporal restrictions of harvest
- B Practices mainly found in local and traditional societies
  - Multiple species management
  - Maintaining ecosystem structure and function
  - Resource rotation
  - Succession management
- C Practices related to the dynamics of complex systems
  - Management of landscape patchiness
  - Watershed-based management
  - Managing ecological processes at multiple scales
  - Responding to and managing pulses and surprises
  - Nurturing sources of ecosystem renewal

2 Social mechanisms behind management practices

- A Generation, accumulation and transmission of local ecological knowledge
  - Reinterpreting signals for learning
  - Revival of local knowledge
  - Folklore and knowledge carriers
  - Integration of knowledge
  - Intergenerational transmission of knowledge
  - Geographical diffusion of knowledge
- B Structure and dynamics of institutions
  - Role of stewards/wise people
  - Cross-scale institutions
  - Community assessments
  - Taboos and regulations
  - Social and religious sanctions
- C Mechanisms for cultural internalization
  - Rituals, ceremonies and other traditions
  - Cultural frameworks for resource management
- D World view and cultural values
  - A world view that provides appropriate environmental ethics
  - Cultural values of respect, sharing, reciprocity and humility

Source: Adapted from Folke et al, 1998a.

Pretty, 2003; Galaz, 2005). Challenges for the social sciences have been raised in this context (e.g. Scoones, 1999; Abel and Stepp, 2003). Social sources of resilience such as social capital (including trust and social networks) and social memory (including experience for dealing with change) (Olick and Robbins, 1998; McIntosh, 2000) are essential for the capacity of social-ecological systems to adapt to and shape change (Folke et al, 2003).

Complex adaptive systems

In our view, social-ecological systems are complex adaptive systems characterized by historical (path) dependency, non-linear (non-convex) dynamics, regime shifts, multiple basins of attraction and limited predictability (Costanza et al, 1993). Theories of complex systems portray systems not as deterministic, predictable and mechanistic, but as process dependent organic and self-organizing with feedbacks between multiple scales (e.g. Kaufmann, 1993; Holland, 1995; Arthur, 1999; Levin, 1999). The ecosystem-based approach recognizes the role of the human dimension in shaping ecosystem processes and dynamics (Dale et al, 2000) and that human actions have pushed ecological systems into less productive or otherwise less desirable states with negative consequences for human livelihood and security. The existence of 'regime shifts' in ecosystems is an area of intense research (Scheffer et al, 2001) with examples from forests, lakes, wetlands, coastal areas, fisheries, coral reefs (Folke et al, 2004), grazing lands (Scholes and Walker, 1993), agriculture (Rockström, 2003) and marine systems (Troell et al, 2005; Grebmeier et al, 2006). In some cases, these shifts may be irreversible or too costly to reverse (Mäler, 2000).

The human dimension reflects properties of complex adaptive systems such as a diverse set of institutions and behaviours, local interactions between actors and selective processes that shape future social structures and dynamics (Holland et al, 1986; Arthur, 1999; Janssen and Jager, 2001; Lansing, 2003). Complexity makes it hard to forecast the future. Not only are forecasts uncertain, the usual statistical approaches will likely underestimate the uncertainties since key drivers like climate and technological change are unpredictable and may change in non-linear fashions (Kinzig et al, 2003; Peterson et al, 2003). Gunderson (2001) nicely illustrates the need for learning and flexibility in the social system when confronted with alternative and uncertain explanations of ecosystem change.

The complex adaptive systems approach shifts the perspective on governance from aiming at controlling change in resource and ecosystems assumed to be stable, to enhancing the capacity of social-ecological systems to learn to live with and shape change and even find ways to transform into more desirable directions following change (van der Leeuw, 2000; Berkes et al, 2003; Norberg and Cumming, 2007).

It is in this context that the *resilience* perspective becomes central. Resilience is the capacity to absorb change, reorganize and continue to develop. The concept of resilience was invented to address the paradox of how change and persistence work together (Holling, 1973). Resilience research addresses how systems assimilate disturbance and make use of change for innovation and development, while simultaneously maintaining characteristic structures and processes (Folke, 2006a). It is argued that managing for resilience enhances the likelihood of sustaining and developing desirable pathways for societal development in changing environments where the future is unpredictable and surprise is likely (Gunderson and Holling, 2002; Adger et al, 2005).

Cross-scale and dynamic interactions

Social-ecological systems are linked across temporal and spatial scales and levels of organization. Human capacities for abstraction and reflexivity, forward-looking action, and technology development are strikingly different from ecological systems (Westley et al, 2002) and enable human systems to transcend constraints of ecological scale. Local groups and communities are subject to decisions from regional levels and connected to global markets and vice versa (Berkes et al, 2006). A social-ecological system can avoid vulnerability at one timescale through the technology it has adopted. Similarly, resilience at one spatial extent can be subsidized from a broader scale, a common pattern in human cultural evolution (Redman, 1999; van der Leeuw, 2000) and exacerbated by technology, capital markets and financial transfers that mask environmental feedback.

Such feedbacks and their cross-scale interactions in relation to resilience are in the focus of a truly integrated social-ecological systems modelling of agents and ecosystem with multiple stable states (e.g. Carpenter et al, 1999; Janssen and Carpenter, 1999; Janssen et al, 2000; Carpenter and Brock, 2004; Bodin and Norberg, 2005). Recent work suggests that complex systems 'stutter' or exhibit increased variance at multiple scales in advance of a regime shift (Carpenter and Brock, 2006). Such increases in variance help characterize regime shifts, and may even allow early warning indicators of some regime shifts. Furthermore, multiple thresholds and regime shifts at different scales and in different and interacting ecological, economic and social domains are proposed to exist within regional social-ecological systems (Kinzig et al, 2006).

New insights are emerging on cross-scale interactions in social-ecological systems (Gunderson and Holling, 2002; Young, 2002; Cash et al, 2006) including dynamics of social and economic drivers of land use change (Lambin et al, 2003) and on governance systems that allow for learning and responding to environmental feedback and change (Dietz et al, 2003). Good ecosystem management requires governance and management approaches that can deal with the change and uncertainty inherent in social-ecological systems and match social and ecological structures and processes operating at different spatial and temporal scales (Folke et al, 1998b; Brown, 2003).

Adaptive Governance for Ecosystem Services

The capacity to adapt to and shape change is an important component of resilience in social-ecological system (Berkes et al, 2003). In a social-ecological system with high adaptability the actors have the capacity to reorganize the system within desired states in response to changing conditions and disturbance events (Walker et al, 2004). This includes social sources of resilience for dealing with uncertainty and change and a focus on adaptive capacity (Folke et al, 2003), learning and innovation in social-ecological systems and even the capacity to transform into improved pathways or trajectories (Folke et al, 2005).

Because of cross-scale interplay, positive feedbacks causing non-linear dynamics and possible shifts between alternate states in interdependent social-ecological systems, new approaches to governance will be required for guiding management and policy of ecosystem services towards sustainability. Based on several case studies Folke et al (2003) identify four critical factors for social-ecological systems that interact across temporal and spatial scales that seem to be required for dealing with ecosystems dynamics during periods of rapid change and reorganization:

1 learning to live with change and uncertainty;
2 combining different types of knowledge for learning;
3 creating opportunity for self-organization toward social-ecological resilience;
4 nurturing sources of resilience for renewal and reorganization.

Governance and management systems have to be designed to incorporate these factors. The emerging perspective of adaptive governance (Dietz et al, 2003; Folke et al, 2005) represents one such approach. Adaptive governance conveys the difficulty of control, the need to proceed in the face of substantial uncertainty, and the importance of dealing with diversity and reconciling conflict among people and groups who differ in values, interests, perspectives, power and the kinds of information they bring to situations (Dietz et al, 2003). Such governance fosters social coordination that enables adaptive co-management of ecosystems. Adaptive co-management combines the dynamic learning characteristic of adaptive management (Gunderson et al, 1995; Carpenter and Gunderson, 2001) with the linkage characteristic of collaborative management (Wollenberg et al, 2000; Gadgil et al, 2000; Ruitenbeek and Cartier, 2001; Folke et al, 2003; Borrini-Feyerabend et al, 2004). For such governance to be effective it requires an understanding of both ecosystems and social-ecological interactions.

Adaptive governance relies on multi-level arrangements, including local, regional, national, transnational and global levels, where authority has been reallocated upward, downward and sideways away from central states. It refers to a type of governance that is dispersed across multiple centres of authority (Hooghe and Marks, 2003), 'pluricentric' rather than 'unicentric' (Kersbergen and Waarden, 2004), and characterized by non-hierarchical methods of control (Ostrom, 1998; Stoker, 1998). The common property resource research refers to such nested, quasi-autonomous decision making units operating at multiple scales as polycentric institutions (Ostrom, 1998; McGinnis, 2000; Dietz et al, 2003).

We have previously proposed that there are, at least, four interacting aspects to be concerned about in adaptive governance of complex social-ecological systems with cross-scale dynamics (Folke et al, 2005).

1 *Building knowledge and understanding of resource and ecosystem dynamics*; detecting and responding to environmental feedback in a fashion that sustains the capacity of the environment to provide ecosystem services requires ecological knowledge and understanding of ecosystem processes and functions (Berkes and Folke, 1998). All sources of understanding need to be mobilized and management of complex adaptive systems may benefit from the combination of different knowledge systems.
2 *Feeding ecological knowledge into adaptive management practices*; successful management is characterized by continuous testing, monitoring, and re-evaluation to enhance adaptive responses acknowledging the inherent uncertainty in complex systems (Carpenter and Gunderson, 2001). It is increasingly proposed that knowledge generation of ecosystem dynamics should be explicitly integrated with adaptive management practices rather than striving for optimization based on past records. This aspect emphasizes a learning environment and knowledge generation with associated institutions (e.g. Brown, 2003). Forming a learning environment that accepts continuous testing and adaptation requires leadership within management organizations (e.g. Danter et al, 2000) and collaboration within social networks (Janssen et al, 2006).
3 *Support flexible institutions and multi-level governance systems*; the adaptive governance framework is operationalized through adaptive co-management where the dynamic learning characteristic of adaptive management is combined with the multi-level linkage characteristic of co-management (Olsson et al, 2004a). The sharing of management power and responsibility may involve multiple often polycentric institutional and organizational linkages among user groups or communities, government agencies, and non-governmental organizations including support from legal, political and financial sources to ecosystem management initiatives.
4 *Deal with external perturbations, uncertainty and surprise;* it is not sufficient for a well functioning multi-level governance system to be in tune with the dynamics of the ecosystems under management. It also needs to develop adaptive capacity for dealing with change in e.g. climate, disease outbreaks, hurricanes, global market demands, subsidies and governmental policies. The challenge for the social-ecological system is to enhance the adaptive capacity to deal with disturbance, to face uncertainty and be prepared for change and surprise. A resilient social-ecological system may even make use of disturbances as opportunities to transform into more desired states. Non-resilient social-ecological systems are vulnerable to external drivers and change.

Management practices for dealing with ecosystem change

Holling (1978) proposed 'Adaptive management' – a constantly changing management system, not only to meet the continuously changing and unpredictable ecosystem, but also to learn from it. Adaptive ecosystem management is an ongoing process, an organized way to deal with uncertainty and learn from management actions (Gunderson et al, 1995). Basically such adaptive management can be divided into:

- A conceptual system model, sometimes expressed as a computer simulation model that represents available knowledge and understanding of the system processes, structure and elements.
- A set of strategies that represents management policies or actions.
- A set of criteria for judging the success of the implementation of management actions and policies.
- A process that continuously evaluates and responds to the effects of management actions on the system and incorporates lessons learned in a new set of strategies to improve management.

Walters (1997) in his review of adaptive management argues that a reason for failure lies in management stakeholders showing deplorable self-interest, seeing adaptive-policy development as a threat to existing research programmes and management regimes, rather than as an opportunity for improvement. This is why it becomes important to address the social dimension and contexts for adaptive governance in relation to ecosystem management such as processes of participation, collective action and learning.

Policy increasingly emphasizes the involvement of local users and land owners in adaptive ecosystem management. Involving local resource users can improve incentives for ecosystem management (Agrawal and Gibson, 1999; Fabricius and Koch, 2004). In addition, traditional and local knowledge about resources and ecosystem dynamics in communities can provide unique information about local conditions and complement scientific knowledge in ecosystem management efforts (e.g. Berkes et al, 2000; Olsson and Folke, 2001; Becker and Ghimire, 2003; Aswani and Hamilton, 2004; Sheil and Lawrence, 2004).

But still few ecological inventories or stakeholder analyses (that tend to focus on conflicting interests) capture human resources in the landscape or the social structures and processes underlying incentives and values for ecosystem management.

Social-ecological inventories and local stewards of ecosystem services

Social-ecological inventories have been suggested to improve ecosystem management (Schultz et al, in press). Such inventories identify people with ecosystem knowledge that practice ecosystem management. Social-ecological inventories help visualize ecosystem management on the ground in relation to ecosystem services, focusing on local steward groups acting outside official management plans. In a social-ecological inventory, conducted in a river basin of southern Sweden, local steward groups, their ecosystem management activities, motives and social networks were identified. Methods included interviews, participatory observations and review of documents and other written material. The inventory revealed a rich diversity of steward groups that manage and monitor a range of ecosystem services at different spatial scales. Contributions of local stewards include on-site ecosystem management, long-term and detailed monitoring of species and ecosystem dynamics, responses to environmental change, generation of local ecological knowledge employed in management practices, public support for ecosystem management and specialized networks (Schultz et al, in press).

Such local stewards of ecosystem services in dynamic landscapes are to be found also in strongly human-dominated environments like urban areas. For example, Colding et al (2006) demonstrate that green spaces such as golf courses, allotment areas and domestic gardens covers more than twice the area of protected lands and are managed by local steward groups below the level of municipalities. These areas play a significant role in urban ecosystem services generation, but they and their stewards are seldom recognized in this capacity in urban planning schemes.

Practices and ecosystem dynamics

Berkes and Folke (1998, 2002) identified management practices of local groups that make ecological sense and where people have developed practices to deal with ecosystem dynamics including abrupt periods of change. Traditional practices for ecosystem management include multiple species management, resource rotation, ecological monitoring, succession management, landscape patchiness management, and practices of responding to and managing pulses and ecological surprises. There exist practices that seem to reduce social-ecological crises in the events of large-scale natural disturbance such as creating small-scale ecosystem renewal cycles, spreading risks and nurturing sources of ecosystem reorganization and renewal (Colding et al, 2003; Folke et al, 2003).

Ecological knowledge and monitoring among local groups appears to be a key element in the development of many of the practices. The practices are linked to social mechanisms such as flexible user rights and land tenure; adaptations for the generation, accumulation and transmission of ecological knowledge; dynamics of institutions; mechanisms for cultural internalization of traditional practices; and associated worldviews and cultural values (Berkes et al, 2000).

There exist numerous resource management practices among local people that have abandoned the steady-state and linear worldview. For example, there are those that *evoke small-scale disturbances* in ecosystems recognizing that change and also abrupt change is part of development. Such practices trigger small-scale release and create smaller renewal cycles in the local ecosystem and may reduce the impact of large-scale natural disturbances (Holling et al, 1998). Examples include shifting cultivation and fire management for habitat improvement. These practices provide for the regeneration of important resources by creating habitat heterogeneity. Pulse fishing, employed by the James Bay Cree, and pulse grazing, employed by some African pastoralists, represents examples of such disturbance practices (Berkes et al, 2000).

Furthermore, there exist local resource management practices that may be important for *dealing with abrupt change* and disturbance events. Polyculture of

Samoa represents an example of such a practice. A minor food crop, yams, became the most important food for an extended period of time following a large-scale cyclone. Polyculture and 'multiple-disturbance tolerant' species among the char-dwellers in Bangladesh serve the same function by reducing the potential impacts of flooding or droughts (Colding et al, 2003). Diversification of livestock species among many pastoral groups in the African Sahel may reduce the effects of various disturbance regimes such as disease outbreaks and droughts.

Locally protected habitats, such as sacred groves, buffer zone areas and range reserves, may be important for the *reorganization* of ecosystems following disturbance events. Such areas may provide dispersal and migration of animals and plants into disturbed ecosystems. Even taboos imposed on populations of common species may have critical functions in the reorganization phase – especially those imposed on mobile link species (Elmqvist et al, 2001; Lundberg and Moberg, 2003; Bodin et al, 2006).

These are examples of practices common in traditional societies and local communities and that help insure the communities against uncertainty in resource flows and make people adaptive to change (Folke et al, 1998a, 2006)

Social taboos and ecosystem services

Successful resource management systems require flexible social mechanisms for continual adjustments to environmental dynamics. Thus, institutional structures (rules and norms in use) are needed to take environmental variability and ecological feedbacks into account and provide capacity for management to respond to such dynamics. We have analysed social taboos in this context, defining a taboo as a prohibition imposed by social custom or as a protective measure. Such institutions are based on cultural norms that are not governed by government for either promulgation or enforcement. In Colding and Folke (2001) social taboos were grouped into six major categories in relation to their resource and ecosystem management functions (Table 7.2). The last two categories of Table 7.2 can be referred

Table 7.2 *Resource and habitat taboos (RHTs) and their nature conservation and resource management functions*

Category	*Function*
Segment taboos	Regulate resource withdrawal
Temporal taboos	Regulate access to resources in time
Method taboos	Regulate methods of withdrawal
Life history taboos	Regulate withdrawal of vulnerable life history stages of species
Specific-species taboos	Total protection to species in time and space
Habitat taboos	Restrict access and use of resources in time and space

Source: Colding and Folke, 2001

to as *non-use taboos*, because they do not allow for human use of biological resources. The other four categories may be referred to as *use-taboos* since the taboos permit restrictive use of resources (Colding and Folke, 2001).

Segment taboos apply when a cultural group bans the utilization of particular species for specific time periods for human individuals of a particular age, sex or social status. Thus, certain segments of a human population may be temporarily proscribed from the gathering and/or consumption of species. This group of taboos exists in a number of traditional societies in e.g. Africa and South America.

Temporal taboos may be imposed *sporadically*, *daily* or on a *weekly* to *seasonal* basis. Cases recorded in the literature derive e.g. from Oceania and India. Such taboos are imposed on both aquatic and terrestrial resources. In an ecological context, they function to reduce harvesting pressure on particular subsistence resources and are closely related to the dynamic change of resource stocks.

Method taboos are imposed on certain gear types and extraction methods that may easily reduce or deplete the stock of a resource. Method taboos are common in South-East Asia and are often fishing-related.

Life history taboos apply when a cultural group bans the use of certain vulnerable stages of a species' life history based on its age, size, sex or reproductive status. Such taboos may be imposed on reproducing and nesting species, and species particularly susceptible to over harvesting, such as slow moving, or sessile, marine species. Examples of such taboos derive mainly from India and Oceania.

Specific-species taboos prohibit any use of particular species and their populations. The reasons for the existence of specific-species taboos vary, ranging from beliefs in species being toxic, serving as religious symbols, representing reincarnated humans, and species being avoided due to their behavioural and physical appearance.

Habitat taboos are often imposed on terrestrial habitats, river stretches, ponds and coastal reefs. Examples of such 'socially fenced' ecosystem types (Colding et al, 2003) include 'sacred groves' of India and Africa, 'spirit sanctuaries' of South America, *waahi tapu* and *ahupua'a* in the South Pacific and *hima* of Saudi Arabia. Habitat taboos provide for the protection of a number of ecological services on which a local community may depend. These services include the maintenance of biodiversity, regulation of local hydrological cycles, prevention of soil erosion, pollination of crops, preservation of locally adapted crop varieties, habitat for threatened species and predators on noxious insect and pest species of crops, and areas serving as wind and fire brakes.

An example from southern Madagascar (Bodin et al, 2006) illustrates the significance of recognizing culturally protected and managed areas (Nabhan, 1997) in the generation of ecosystem services, like allotment areas or golf courses in the urban context (Colding et al, 2006). In Madagascar the landscape is heavily fragmented, except for small forest patches that hold an abundance of rare species serving as refuges. Analyses of movements of animals illustrate that the landscape due to the small patches is fairly well connected despite the fragmentation and that the forest patches support, e.g. pollination of staple crops in local livelihoods

(Bodin et al, 2006). A national government or an international conservation NGO may conclude that to conserve biodiversity (the rare species) and ecosystem services of the landscapes these forest patches need to be urgently protected from human use and abuse and transformed into no-take areas through legal protection or governmental intervention. But a social-ecological inventory would reveal that they are in fact already protected by a social taboo system of sacred forests (Schultz et al, in press). As a matter of fact, it is such systems that have sustained the biota and ecosystems services of the landscape. Implementing top down policies may disrupt such socially and culturally enforced systems that sustain ecosystem services.

Hence, lack of policy recognition of the social and cultural dimension at local scales of ecosystem management may degrade landscapes further. However, with the information in mind of the significance of the sacred forests and the social taboos, the NGO and the national government could help secure such management institutions, for example, through what Ostrom and Schlager (1996) refer to as umbrella organizations or Alcorn and Toledo (1998) as tenural shells. This becomes increasingly significant in the face of large-scale economic drivers of change or incorporations into global cultures and value systems.

When people comply with self-enforced norms, economic transaction costs may be low relative to formal enforcement measures. During such conditions institutions, like social taboos, may provide for (1) low monitoring costs, (2) low enforcement costs, and in many cases (3) low sanctioning costs (Colding and Folke, 2001). Incentives should be created that strengthen social networks of steward groups for ecosystem management in multi-level governance systems (Folke et al, 2005). It is time to move conservation beyond confrontation to multi-level collaboration (Wondolleck and Yaffe, 2000; Folke, 2006a) and recognize that ecosystem management is to a large extent people's management (Berkes, 2004).

Social networks, ecosystem management and bridging organizations

Ecosystem management is an information-intensive endeavour and requires knowledge of complex social-ecological interactions in order to monitor, interpret, and respond to ecosystem feedback at multiple scales (Imperial, 1999a, 1999b; Folke et al, 2003). We have earlier argued that it is difficult if not impossible for one or a few people to possess the range of knowledge needed for ecosystem management (Olsson et al, 2004a). Instead, knowledge for dealing with social-ecological systems dynamics is dispersed among individuals and organizations in society and requires social networks that span multiple levels in order to draw on dispersed sources of information (Olsson et al, 2006).

In this sense, knowledge of ecosystem dynamics resides in networks. A challenge is to identify mechanisms for organizing relations between relatively autonomous, but interdependent actors (Kersbergen and Waarden, 2004) and avoid fragmented and sectoral approaches to the ecosystem management. Several studies have looked at the role of social networks in inter-organizational collaboration and collective action in relation to natural resource management (e.g. Agranoff and McGuire, 1999, 2001; Mandell, 1999; Carlsson, 2000; Mandell and Steelman, 2003; Imperial, 2005). A challenge is to identify social mechanisms and enabling institutional arrangements that can mobilize knowledge at critical times.

There is a need to increase the understanding of the role of networks in adaptive governance of social-ecological systems and mechanisms for facilitating cross-scale interactions, dealing with uncertainty and change, and enhancing ecosystem management (Bodin and Norberg, 2005; Janssen et al, 2006). Westley (2002) argues that the capacity to deal with the interactive dynamics of social and ecological systems requires networks of interacting individuals and organizations at different levels to create the right links, at the right time, around the right issues.

The Ecomuseum of the Kristianstads Vattenrike is an example of an organization that creates a bridge between local actors and communities with other organizational levels (Olsson et al, 2004b). *Bridging organizations* increase the potential to redirect external forces into opportunities, serve as catalysts and facilitators between different levels of governance and bring in resources, knowledge and other incentives for ecosystem management (Folke et al, 2005). A bridging organization like the Ecomuseum Kristianstads Vattenrike provides an arena for trust-building, sense-making, learning, vertical and horizontal collaboration and conflict resolution (Hahn et al, 2006). It uses networks of local steward groups to mobilize knowledge and social memory, which in turn help deal with uncertainty and shape change (Folke et al, 2003, 2005). The different networks and the numerous linkages that can be activated when needed contribute to the robustness of the social-ecological system and therefore are sources of social-ecological resilience. They constitute the social memory (in the sense of Macintosh, 2000) that can be mobilized at critical times and increase response options to deal with uncertainty and change.

The adaptive co-management and the adhocracy in Kristianstads Vattenrike rely on sleeping links that can be activated when there is a conflict or crisis and the Ecomuseum helps to mobilize experience and social memory for dealing with change (Hahn et al, 2006). Thus, bridging organizations can play a crucial role in the dynamic relationship between key individuals, social memory and resilience. Such structures of social capital need to be recognized and nurtured in conservation and ecosystem management efforts.

Leadership and actor groups

A key mechanism behind adaptive co-management is leadership which can come in different forms. For example, key individuals can provide visions of ecosystem management and sustainable development that frame self-organizing processes (Agranoff and McGuire, 2001; Westley, 2002). Key stewards are important in establishing functional links within and between organizational levels and therefore facilitating the flow of information and knowledge from multiple sources to be applied in the local context of ecosystem management. Social networks often emerge as self-organizing processes (i.e. not implemented by external pressure) involving key persons who share some common interests although they represent different stakeholder groups (McCay, 2002). Leadership has been showed to be of great significance for public network management. Network leadership and guidance is very different from the command and control of hierarchical management (Agranoff and McGuire, 2001). It requires steering for the network to hold together (Bardach, 1998) and a balancing of social forces and interests that enables self-organization (Kooiman, 1993).

However, social-ecological systems that rely on one or a few key stewards might be vulnerable to change. This is exemplified by Peterson (2002) who describes the management of the long-leaf pine forest in Florida and how the desirable state or the stability domain of the forest is maintained by fire as a main structuring variable. Fire frequency has decreased in the area and long-leaf pine forest ecosystems therefore risk entering into other less desirable ecosystem states. The forest is within a military base and an air force general has been a key steward for maintaining the forest through active burning. When the general left his position, a new general who did not share the interests and convictions of his predecessor replaced him. However, some of the personnel who had taken an active part in ecosystem management had developed knowledge and affection for the long-leaf pine forests. They also used a scientist's model of forest dynamics to successfully convince the new general of the importance of fire management for maintaining the desirable stability domain of a long-leaf pine forest ecosystem. This example shows how structures and processes such as social networks can provide a social memory of ecosystem management that sustains adaptive capacity in times of change.

The strength of networks depends on the ability of the key persons to exchange information with other stakeholders, identify common interests and gather support for such interests (e.g. ecosystem management) within their own organization or stakeholder group. Bardach (1998) describes how leaders play different roles in systems of strategic interaction which include eliciting common goals, creates an atmosphere of trust, brokers organizational and individual contributions, and deploys energies in accord with some strategic plan. Organizations that do not appear to have much in common may develop crucial links thanks to these key persons who form the nodes of different, loosely connected, networks. In his seminal paper, Granovetter (1973) argued that weak ties, i.e. the bridges between different stakeholder groups, may be the most valuable for generating new knowledge and identifying new opportunities and hence create a macro effect: 'those to whom we are weakly tied are more likely to move in circles different from our own and will thus have access to information different from that which we receive' (p1371). Applied to ecosystem management, we argue that a loosely connected network involving a diversity of stakeholders is important for gathering different types of ecological knowledge, build moral and political support (legitimacy) from 'non-environmental' sectors, and attain legal and financial support from various institutions and organizations. Hence, if polycentric cross-level institutions provide the structure for adaptive co-management, multiple-overlapping networks of key persons provide the processes.

As an example, Bebbington (1997) identifies brokers as key stewards in sustainable agriculture intensification in the Andes, including their role in coordinating social networks in the management process. In all the cases of sustainable intensification, outsiders have played a key role in bringing in new ideas, but more importantly they have brought in networks of contacts. These brokers had different backgrounds, including a priest, university professor, European volunteers and funding agencies. The connections they brought with them helped the members of the local communities gain access to non-local institutions and resources, including access to NGOs with technical assistance and financial resources, sources of technology, donors, and alternative trading networks. These networks spread across national and international boundaries in ways that would have been hard for the locals to do on their own.

In addition to leaders, we have previously identified other essential actors and actor groups that serve social mechanisms in adaptive co-management networks: knowledge carriers, knowledge generators, stewards and sense-makers. Folke et al (2003), based on several case studies, identified the following actor groups: knowledge retainers, interpreters, facilitators, visionaries, inspirers, innovators, experimenters, followers and reinforcers. In coastal communities of Eastern Africa, actor groups like beach recorders of fish catches and middlemen that link fishers to markets are of major significance in shaping exploitation patterns of coastal and marine ecosystems and thereby influencing the capacity of these social-ecological systems to generate and sustain ecosystem services (de la Torre-Castro, 2006; Crona, 2006). Holling and Chambers (1973), in their analyses of social roles in resource management workshops, stressed the importance of also including individuals with opposite views that oppose and criticize. These roles of actor groups are all important components of social networks and essential for creating the conditions that we argue are necessary for ecosystem management.

Transforming Social-ecological Systems

Crisis, perceived or real, seems to trigger learning and knowledge generation (Westley, 1995) and opens up space for combinations of different social memories and new management trajectories of resources and ecosystems (Gunderson, 2003). Olsson and Folke (2001) described how threats of acidification, overfishing and disease successively initiated learning and generated knowledge and institutions for landscape management among local groups in the Lake Racken catchment in western Sweden. Based on empirical work Olsson et al (2004a) observed the following sequence of local self-organizing toward adaptive co-management of ecosystems.

- A sequence of social responses to environmental events widens the scope of local management from a particular issue or resource to a broad set of issues related to ecosystems processes across scales.
- Management expands from individual actors, to a group of actors to multiple-actor processes.
- Organizational and institutional structures evolve as a response to deal with the broader set of environmental issues.
- Knowledge of ecosystem dynamics develops as a collaborative effort and becomes part of the organizational and institutional structures.
- Social networks develop that connect institutions and organizations across levels and scales and facilitate information flows, identify knowledge gaps and create nodes of expertise of significance for ecosystem management.
- Knowledge for ecosystem management is mobilized through social networks and complements and refines local practice for ecosystem management.
- In the time series of events the ability to deal with uncertainty and surprise is improved which increases the adaptive capacity to deal with future change.

The crises that trigger such self-organization may be caused by external markets and tourism pressure, floods and flood management, shifts in property rights, threats of acidification, resource failures, rigid paradigms of resource management, new legislation or governmental policies that do not take into account local contexts (Berkes et al, 2003). A social-ecological system with low levels of social capital and social memory is vulnerable to such changes and may as a consequence shift into undesired pathways (Gunderson and Holling, 2002).

In contrast, crisis may trigger social capital and social memory to be mobilized and combined into new forms of governance systems with the ability to manage dynamic ecosystems and landscapes. This has been referred to as building social capacity for resilience in social-ecological systems (Folke et al, 2003) and it requires evoking change in social structures (Westley, 1995). Key individuals with strong leadership may catalyse opinion shifts (Gladwell, 2000; Scheffer et al, 2003) and creative teams and actor groups that emerge into a large connected community of practitioners can prepare a social-ecological system for rapid change (Blann et al, 2003; Guimera et al, 2005) and transform it into a new pathway of development.

Transformability means creating and defining a new attractor that directs the development of the social-ecological system by introducing new components and ways of making a living, thereby changing the state variables, and often the scales of key cycles, that define the system (Walker et al, 2004).

Transformations toward alternative forms of governance has been addressed by Kettl (2000), Kuks and Bressers (2004) and Agrawal (2005). Olsson et al (2004b) analysed the emergence of a governance system for adaptive co-management of the wetland landscape of Kristianstad in southern Sweden, a process where unconnected management by several actors in the landscape was mobilized, renewed and moved into a new configuration of ecosystem management within about a decade.

The self-organizing process was triggered by the perceived threats to the area's cultural and ecological values among people of various local steward associations and local government. A key individual provided visionary leadership in directing change and transforming governance. The transformation involved four phases

1 preparing the system for change;
2 the opening of an opportunity;
3 navigating the transition;
4 charting a new direction for building resilience of the new governance regime.

Trust-building dialogues, mobilization of social networks with actors and teams across scales, coordination of ongoing activities, sense-making, collaborative learning and creating public awareness were part of the process. A comprehensive framework with a shared vision and goals that presented ecosystem management as development and turned problems into opportunities was developed and contributed to a shift in values and meaning of the broader agricultural-urban-wetland landscape among key actors. When a window of opportunity at the political level opened, it was possible to tip and transform the governance system into a trajectory of adaptive co-management with extensive social networks of practitioners engaged in multi-level governance. The transformation took place within the existing legal and formal institutional framework (Hahn et al, 2006). Currently adaptive capacity is built to make the new social-ecological configuration resilient to change. Strategies for adaptive capacity are presented in Table 7.3.

Understanding the sources of resilience that allow for mobilization of social capital and memory to generate novelty and innovation for transformation of social-ecological systems into improved pathways of development is a central issue for sustainability research.

Conclusions

We have only scratched the surface of an immense research challenge that promises to provide a much richer understanding of not just human–environment interactions but of how the world we live in actually works and the implications it has for current policies and governance. The chapter emphasizes that the social landscape should be approached as carefully as the ecological in order to clarify features that contribute to the resilience of social-ecological systems. In this context, Pretty and Ward (2001) find that relations of trust, reciprocity, common rules, norms and sanctions, and connectedness in institutions are critical. We have similar findings that include vision, leadership and trust; enabling legislation that creates social space for ecosystem management; funds for responding to environmental change and for remedial action; capacity for monitoring and responding to environmental

Table 7.3 *Processes and strategies in Kristianstads Vattenrike that increase capacity for dealing with uncertainty and change*

Developing motivation and values for ecosystem management
• Envisioning the future together with actors • Developing, communicating and building support for the mission • Identifying and clarifying objectives • Developing personal ties • Establishing a close relationship and trust with key individuals • Fostering dialogue with actors • Providing arenas for trust-building among actors • Building trust in times of stability to facilitate conflict resolution • Developing norms to avoid loss of trust among actors • Continuously communicating success and progress of projects
Directing the local context through adaptive co-management
• Encouraging and supporting actors to perform monitoring, including inventories • Encouraging and supporting actors to manage ecosystem processes for biodiversity and ecosystem services • Initiating and sustaining social networks of key individuals • Mobilizing individuals of social networks in problem-driven projects • Making sense of and guiding the management process • Synthesizing and mobilizing knowledge for ecosystem management • Providing coordination of project and arenas for collaboration • Encouraging and inspiring actors to voluntary participation • Initiating projects and selecting problems that can be turned into possibilities • Creating public opinion and involving local media
Navigating the larger environment
• Influencing decision makers at higher levels to maintain governance structures that allow for adaptive co-management of the area • Mobilizing new funding when needed • Mobilizing external knowledge when needed • Exchanging information and collaboration with local steward associations in Sweden and internationally • Collaborating with national and international scientists • Collaborating with national and international non-governmental organizations • Participating in international institutional frameworks • Supporting diffusion of the values of KV through social networks • Providing a buffer for external drivers • Communicating with national media

Source: Adapted from Olsson et al, 2004b

feedback; information flow through social networks; the combination of various sources of information and knowledge; sense-making and arenas of collaborative learning for ecosystem management. Our work illustrates that the interplay between individuals (e.g. leadership, teams, actor groups), the emergence of nested organizational structures, institutional dynamics and power relations tied together in dynamic social networks are examples of features that seem critical in adaptive governance that allows for ecosystem management and for responding to environmental feedback across scales.

An important lesson from the research is that it is not enough to create arenas for dialogue and collaboration, nor is it enough to develop networks to deal with issues at a landscape level. Further investigation of the interplay between key individuals, actor groups, social networks, organizations and institutions in multi-level social-ecological systems in relation to adaptive capacity, cross-scale interactions and enhancement of resilience is needed. We have to understand, support and perhaps even learn how to actively navigate the underlying social structures and processes in the face of change. There will be inevitable and possibly large-scale environmental changes and preparedness has to be built to enhance the social-ecological capacity to respond, adapt to and shape our common future and make use of creative capacity to find ways to transform into pathways of improved development. We conclude that the existence of transformative capacity is essential in order to create social-ecological systems with the capability to manage ecosystems sustainably for human well-being. Adaptive capacity will be needed to strengthen and sustain such systems in the face of external drivers and events.

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8

Agroecology and Agroecosystems

Stephen R. Gliessman

Agriculture is more than an economic activity designed to produce a crop or to make as large a profit as possible on the farm. A farmer can no longer pay attention to the objectives and goals for his or her farm only and expect to adequately deal with the concerns of long-term sustainability. Discussions about sustainable agriculture must go far beyond what happens within the fences of any individual farm. Farming is now viewed as a much larger system with many interacting parts, including environmental, economic and social components (Gliessman, 2001; Flora, 2001). It is the complex interaction and balance among all of these parts that has brought us together to discuss sustainability, to determine how to move toward this broader goal, and to learn how an agroecological perspective focused on sustainable agroecosystems is a way to achieve these long-term objectives.

Much of modern agriculture has lost the balance needed for long-term sustainability (Kimbrell, 2002). With their excessive dependence on fossil fuels and external inputs, most industrialized agroecosystems are overusing and degrading the soil, water, genetic and cultural resources upon which agriculture has always relied. Problems in sustaining agriculture's natural resource foundation can only be masked for so long by modern practices and high input technologies. In a sense, as we borrow ever-increasing amounts of water and fossil fuel resources from future generations, the negative impacts on farms and farming communities will continue to become more evident. The conversion to sustainable agroecosystems must become our goal (Gliessman, 2001).

In an attempt to clarify my own thinking about agroecosystems, I often think of agriculture as a stream, and farms are different points along that stream. When we think of an individual farm as a 'pool' in a calm eddy at some bend in the stream's flow, we can imagine how many things 'flow' into a farm, and we also expect that many things flow out of it as well. As a farmer, I work hard to keep my pool in the stream (my farm) clean and productive. I try to be as careful as possible in terms of how I care for the soil, which crops I plant, how I control pests and diseases, and how I market my harvest. Back in the days when there were fewer farms, fewer people to

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feed and smaller demands on farmers and farmland, I could keep my farm in pretty good shape. I could keep my pool in the stream pretty clean and did not have to worry very much about what was going on 'downstream' from my farm.

But such a strategy has become much more difficult today. I find that I have less and less control over what comes into my pool. I face a variety of 'upstream impacts' that in combination can threaten the sustainability of my farm. These include the inputs into my farm that either I purchase or which arrive from the surrounding area. They include labour availability and cost, market access for what I produce, legislated policies that determine how much water I use, pesticides I apply, or how I care for my animals – not to mention the vagaries of the weather! My pool can become quickly muddied.

I must also increasingly consider how the way I take care of my pool can have 'downstream effects' in the stream below. Soil erosion and groundwater depletion can negatively affect farms other than my own. Inappropriate or inefficient use of pesticides and fertilizers can contaminate the water and air, as well as leave potentially harmful residues on the food that my family and others will consume. How well I do on my farm is reflected in the viability of rural farm economies, our local community and society broadly. Key indicators are the losses of farmland to other activities and the loss of family farms in general. Both upstream and downstream factors are linked in complex ways, often beyond my control, and they impinge upon the sustainability of my farm.

The Agroecology Perspective

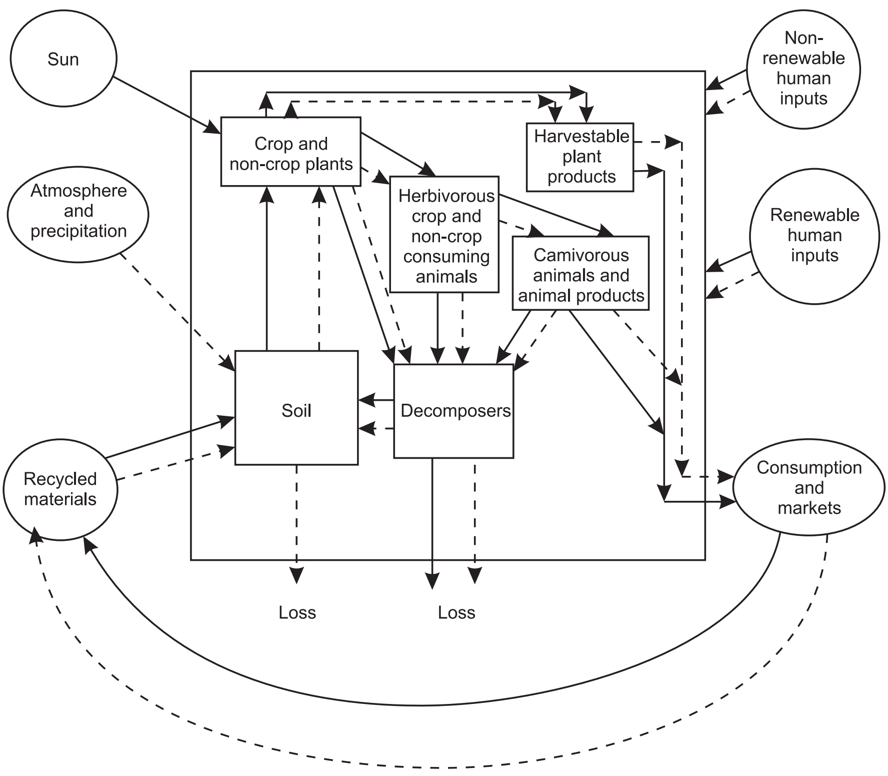
The agroecosystem

Any definition of sustainable agriculture must include how we examine the production system as an agroecosystem. We need to look at the entire system, the entire stream in the above analogy. This definition must move beyond the narrow view of agriculture that focuses primarily on the development of practices or technologies designed to increase yields and improve profit margins. These practices and technologies must be evaluated on their contributions to the overall sustainability of the farm system. The new technologies have little hope of contributing to sustainability unless the longer-term, more complex impacts of the entire agricultural system are included in the evaluation. The agricultural system is an important component of the larger food system (Francis et al, 2003).

A primary foundation of agroecology is the concept of the ecosystem, defined as a functional system of complementary relations between living organisms and their environment, delimited by arbitrarily chosen boundaries, which in space and time appears to maintain a steady yet dynamic equilibrium (Odum, 1996; Gliessman, 1998). Such an equilibrium can be considered to be sustainable in a definitive sense. A well-developed, mature natural ecosystem is relatively stable, self-sustaining, recovers from disturbance, adapts to change, and is able to maintain productivity through using energy inputs of solar radiation alone. When we expand the ecosystem concept to agriculture and consider farm systems as agroecosystems, we have a basis for looking beyond a primary focus on traditional and easily measured system outputs (yield or economic return). We can instead look at the complex set of biological, physical, chemical, ecological and cultural interactions determining the processes that permit us to achieve and sustain yields.

Agroecosystems are often more difficult to study than natural ecosystems because they are complicated by human management, which alters normal ecosystem structures and functions. There is no disputing the fact that for any agroecosystem to be fully sustainable, a broad series of interacting ecological, economic and social factors and processes must be taken into account. Still, ecological sustainability is the building block upon which other elements of sustainability depend.

An agroecosystem is created when human manipulation and alteration of an ecosystem take place for the purpose of establishing agricultural production. This introduces several changes in the structure and function of the natural ecosystem (Figure 8.1) and resulting changes in a number of key system-level qualities. These



Note: Solid lines are energy flow, and dotted lines are nutrient cycles. This model assumes that nutrients and leftover energy are returned to the agroecosystem as reusable materials, and that the use of non-renewable human inputs is minimized.

Figure 8.1 *Functional and structural components of an ecosystem converted to a sustainable agroecosystem* qualities are often referred to as the emergent qualities or properties of systems, qualities that manifest themselves once all of the component parts of the system are organized. These same qualities can also serve as indicators of agroecosystem sustainability (Gliessman, 2001). Four key emergent qualities of ecosystems and how they are altered as they are converted to agroecosystems are discussed in the following sections.

Energy flow

Energy flows through a natural ecosystem as a result of complex sets of trophic interactions, with certain amounts being dissipated at different stages along the food chain, and with the greatest amount of energy within the system ultimately moving along the detritus pathway (Odum, 1971). Annual production of the system can be calculated in terms of net primary productivity or biomass, each component with its corresponding energy content. Energy flow in agroecosystems is altered greatly by human interference (Rappaport, 1971; Pimentel and Pimentel, 1997). Although solar radiation is obviously the major source of energy, many inputs are derived from human-manufactured sources and are most often not self-sustaining. Agroecosystems too often become through-flow systems, with a high level of fossil fuel input and considerable energy directed out of the system at the time of each harvest. Biomass is not allowed to otherwise accumulate within the system or contribute to driving important internal ecosystem processes (e.g. organic detritus returned to the soil serving as an energy source for microorganisms that are essential for efficient nutrient cycling). For sustainability to be attained, renewable sources of energy must be maximized, and energy must be supplied to fuel the essential internal trophic interactions needed to maintain other ecosystem functions.

Nutrient cycling

Small amounts of nutrients continually enter an ecosystem through several hydrogeochemical processes. Through complex sets of interconnected cycles, these nutrients then circulate within the ecosystem, where they are most often bound in organic matter (Borman and Likens, 1967). Biological components of each system become very important in determining how efficiently nutrients move, ensuring that minimal amounts are lost from the system. In a mature ecosystem, these small losses are replaced by local inputs, maintaining a nutrient balance. Biomass productivity in natural ecosystems is linked very closely to the annual rates at which nutrients are able to be recycled. In an agroecosystem, recycling of nutrients can be minimal, and considerable quantities are lost from the system with the harvest or as a result of leaching or erosion due to a great reduction in permanent biomass levels held within the system (Tivy, 1990). The frequent exposure of bare soil between crop plants during the season, or in open fields between cropping seasons, creates 'leaks' of nutrients from the system. Modern agriculture has come to rely heavily upon nutrient inputs derived or obtained from petroleum-based sources to replace these losses. Sustainability requires that these leaks be reduced to a minimum and recycling mechanisms be reintroduced and strengthened. Ultimately, human societies need to find ways to return nutrients consumed in agricultural products back to the fields, the agroecosystems that consumed and produced them in the first place.

Population regulating mechanisms

Through a complex combination of biotic interactions and limits set by the availability of physical resources, population levels of the various organisms are controlled, and thus eventually link to and determine the productivity of an ecosystem. Selection through time tends toward the establishment of the most complex structure biologically possible within the limits set by the environment, permitting the establishment of diverse trophic interactions and niche diversification. Due to human-directed genetic selection and domestication, as well as the overall simplification of agroecosystems (i.e. the loss of niche diversity and a reduction in trophic interactions), populations of crop plants or animals are rarely self-reproducing or self-regulating. Human inputs in the form of seed or control agents, often dependent on large energy subsidies, determine population sizes. Biological diversity is reduced, natural pest control systems are disrupted, and many niches or microhabitats are left unoccupied. The danger of catastrophic pest or disease outbreak is high, often despite the availability of intensive human interference and inputs. A focus on sustainability requires the reintroduction of the diverse structures and species relationships that permit the functioning of natural control and regulation mechanisms. We must learn to work with and profit from diversity, rather than focus on agroecosystem simplification.

Dynamic equilibrium

The species richness or diversity of mature ecosystems permits a degree of resistance to all but very damaging perturbations. In many cases, periodic disturbances ensure the highest diversity, and even highest productivity (Connell, 1978). System stability is not a steady state, but rather a dynamic and highly fluctuating one that permits ecosystem recovery following disturbance. This promotes the establishment of an ecological equilibrium that functions on the basis of sustained resource use which the ecosystem can maintain indefinitely and which can even shift if the environment changes. At the same time, rarely do we witness what might be considered large-scale disease outbreaks in healthy, balanced ecosystems. With a reduction of natural structural and functional diversity, much of the resilience of the system is lost, and constant human-derived external inputs must be maintained. An overemphasis on maximizing harvest outputs upsets the former equilibrium and leads to a dependence on outside interference. To reintegrate sustainability, the emergent qualities of system resistance and resiliency must once again play a determining role in agroecosystem design and management.

We need to be able to analyse both the immediate and future impacts of agroecosystem design and management so we can identify the key areas in each system on which to focus the search for alternatives or solutions to problems. We must learn to be more competent in our agroecological analysis in order to avoid problems or negative changes before they occur, rather than struggling to reverse the problems after they have been created. The agroecological approach provides us one such alternative (Altieri, 1995; Gliessman, 1998).

Applying Agroecology

The process of understanding agroecosystem sustainability has its foundations in two kinds of ecosystems: natural ecosystems and traditional (also known as local or indigenous) agroecosystems. Both provide ample evidence of having passed the test of time in terms of long-term productive ability, but each offers a different knowledge base from which to understand this ability. Natural ecosystems are reference systems for understanding the ecological basis for sustainability in a particular location. Traditional agroecosystems provide many examples of how a culture and its local environment have co-evolved with time through processes that balance the needs of people, expressed as ecological, technological, and socioeconomic factors. Agroecology, defined as the application of ecological concepts and principles to the design and management of sustainable agroecosystems (Gliessman, 1998), draws on both to become a research approach that can be applied to converting unsustainable and conventional agroecosystems into sustainable ones.

Natural ecosystems reflect a long period of evolution in the use of local resources and adaptation to local ecological conditions. They have each become complex sets of plants and animals that co-inhabit a given environment, and as a result, provide extremely useful information for the design of more locally adapted agroecosystems. As I have suggested (Gliessman, 1998), 'the greater the structural and functional similarity of an agroecosystem to the natural ecosystems in its biogeographical region, the greater the likelihood that the agroecosystem will be sustainable'. If this suggestion holds true, natural ecosystem structures and functions can be used as benchmarks or threshold values for more sustainable systems. Scientists have begun to explore how an understanding of natural ecosystems can be used to guide our search for sustainable agroecosystems that respect and protect the environment and natural resources (Soule and Piper, 1992; Jackson and Jackson, 2002).

Traditional and indigenous agroecosystems are different from conventional systems in that they developed originally in times or places where inputs other than human labour and local resources were generally not available or desirable to the local people. Production takes place in ways that demonstrate people's concerns about long-term sustainability of the system, rather than solely maximizing output and profit. Traditional systems continue to be important as the primary sources of food production for a large part of the populations of many developing countries, while at the same time maintaining their foundations in ecological knowledge (Wilken, 1988; Altieri, 1990). This reality demonstrates their importance for the development of sustainable agroecosystems. This is especially true today when so many modern conventional agroecosystems have caused severe degradation of their ecological foundations, as socioeconomic factors have become the predominant forces in the food system (Altieri, 1990). Many traditional agroecosystems are actually very sophisticated examples of the application of ecological knowledge, and can serve as the starting point for the conversion to more sustainable agroecosystems in the future. The traditional Mesoamerican intercrop of corn (*Zea mays* L.), bean and squash is a well-known cropping system where higher yields in the mixtures come about due to a complex of interactions among components of the agroecosystem (Amador and Gliessman, 1990). Examples of such interactions range from the increased presence of beneficial insects due to attractive microclimates and a greater abundance of pollen and nectar sources (Letourneau, 1986), to biologically fixed nitrogen being made available to corn through mycorrhizal fungi connections with roots of bean (Bethlenfalvay et al, 1991).

How can agroecology link our understanding of natural ecosystem structure and function with the knowledge inherent in traditional agroecosystems? On the one hand, the knowledge of place that comes from understanding local ecology is an essential foundation. Another is the local experience with farming that has its roots in many generations of living and working within the limits of that place. We put both of these approaches together when we work with farmers going through the transition process to more environmentally sound management practices, and thus realize the potential for contributing to long-term sustainability. This transition is already occurring. Many farmers, despite the heavy economic pressure on agriculture, are in the process of converting their farms to more sustainable design and management (National Research Council, 1989; OAC/SCOAR, 2003). In California the dramatic increase in organic acreage for a range of crops has been based largely on farmer innovation (Swezey and Broome, 2000). It is incumbent that agroecologists play an important role in contributing to this conversion process.

Converting an agroecosystem to a more sustainable design is a complex process. It is not just the adoption of a new practice or a new technology. There are no silver bullets. Instead, this conversion uses the agroecological approach described above. The farm is perceived as part of a larger system of interacting parts, an agroecosystem. We must focus on redesigning that system in order to promote the functioning of an entire range of different ecological processes (Gliessman, 1998). In a study of the conversion of conventional strawberries (*Fragaria Ananassa* Rozier) to organic management, several changes were observed (Gliessman et al, 1996). As the use of synthetic chemical inputs was reduced or eliminated and recycling was emphasized, agroecosystem structure and function changed as well. A range of processes and relationships began to transform, beginning with improvement in basic soil structure, an increase in soil organic matter content, and greater diversity and activity of beneficial soil biota. Major changes began to occur in the activity and relationships among weed, insect and pathogen populations, and in the functioning of natural control mechanisms. For example, predatory mites

Table 8.1 *Guiding principles for the process of conversion to sustainable agroecosystems design and management*

- Shift from through-flow nutrient management to recycling of nutrients, with increased dependence on natural processes, such as biological N fixation and mycorrhizal relationships
- Use renewable sources of energy instead of non-renewable sources
- Eliminate the use of non-renewable off-farm human inputs that have the potential to harm the environment or the health of farmers, farm workers or consumers
- When materials must be added to the system, use naturally occurring materials instead of synthetic, manufactured inputs
- Manage pests, diseases and weeds instead of 'controlling' them
- Re-establish the biological relationships that can occur naturally on the farm instead of reducing and simplifying them
- Make more appropriate matches between cropping patterns and the productive potential and physical limitations of the farm landscape
- Use a strategy of adapting the biological and genetic potential of agricultural plant and animal species to the ecological conditions of the farm rather than modifying the farm to meet the needs of the crops and animals
- Value most highly the overall health of the agroecosystem rather than the outcome of a particular crop system or season
- Emphasize conservation of soil, water, energy and biological resources
- Incorporate the idea of long-term sustainability into overall agroecosystem design and management

Source: modified from Gliessman, 1998

gradually replaced the use of synthetic acaracides for the control of two-spotted spider mites (*Tetranychus urticae* Koch), the most common arthropod pest in strawberries in California.

Ultimately, nutrient dynamics and cycling, energy use efficiency and overall agroecosystem productivity are affected. Changes may be required in day-to-day management of the farm, planning, marketing and even philosophy. The specific needs of each agroecosystem will vary, but the principles for conversion listed in Table 8.1 can serve as general guidelines for working through the transition. It is the role of the agroecologist to help the farmer measure and monitor these changes during the conversion period in order to guide, adjust and evaluate the conversion process. Such an approach provides an essential framework for determining the requirements for and indicators of sustainable agroecosystem design and management.

Comparing ecosystems and agroecosystems

The key to developing sustainability is building a strong ecological foundation under the agroecosystem, using the ecosystem knowledge inherent to agroecology as discussed above. This foundation then serves as the framework for producing the sustainable harvests needed by humans. In order to maintain sustainable harvests, though, human management is a requirement. Agroecosystems are not self-sustaining, but rely on natural processes for maintenance of their productivity. An agroecosystem's resemblance to natural ecosystems allows the system to be sustained, in spite of the long-term human removal of biomass, without large subsidies of non-renewable energy and without detrimental effects on the surrounding environment.

Table 8.2 compares natural ecosystems with three types of agroecosystems in terms of several ecological criteria. Traditional agroecosystems most closely resemble natural ecosystems, since they most often are focused on the use of locally available and renewable resources, local use of agricultural products and the return of biomass to the farming system. Sustainable agroecosystems are very similar in many properties, but they are more dissimilar in others because of the probable focus on export of harvest to distant markets, the need to purchase a significant part of their nutrients externally and the much stronger impact of market systems on agroecosystem diversity and management. Compared with conventional systems, sustainable agroecosystems have somewhat lower and more variable yields

Table 8.2 *Emergent properties of natural ecosystems, traditional agroecosystems, conventional agroecosystems and sustainable agroecosystems*

Emergent ecological property	*Natural ecosystem*	*Agroecosystem type*		
		Traditional	*Conventional*	*Sustainable*
Productivity (process)	medium	medium	low/med	med/high
Species diversity	high	med/high	low	medium
Structural diversity	high	med/high	low	medium
Functional diversity	high	med/high	low	med/high
Output stability	medium	high	low/med	high
Biomass accumulation	high	high	low	med/high
Nutrient recycling	high	high	low	high
Tropic relationships	high	high	low	med/high
Natural population regulation	high	high	low	med/high
Resistance	high	high	low	medium
Resilience	high	high	low	medium
Dependence on external human inputs	low	low	high	medium
Autonomy	high	high	low	high
Human displacement of ecological processes	low	low	high	low/med
Sustainability	high	med/high	low	high

Source: Modified from Odum (1984), Conway (1985), Altieri (1995) and Gliessman (1998)
Note: Agroecosystem properties are most applicable to the farm scale and for the short- to medium-term time frame.

due to the weather variation that occurs from year to year. Such reductions in yields can be more than offset, from the perspective of sustainability, through the advantages gained in reduced dependence on external inputs, more reliance on natural controls of pests, and reduced negative off-farm impacts of farming activities.

Future Perspectives

Problems in agriculture create the pressures for the changes that will bring about a sustainable agriculture. However, it is one thing to express the need for sustainability, and quite another to actually quantify it and bring about the changes that are required. Designing and managing sustainable agroecosystems, as an approach, is in its formative stages. Initially it builds upon the fields of ecology and agricultural science and is emerging as the science of agroecology. This combination can play an important role in developing the understanding necessary for a transition to sustainable agriculture.

But sustainable agriculture is more. It takes on a cultural perspective as the concept expands to include humans and their impacts on agricultural environments. Agricultural systems are a result of the co-evolution that occurs between culture and environment, and a sustainable agriculture values the human as well as the ecological components. Our small pool in the stream becomes the focal point for changing how we do agriculture, but that change must occur in the context of the human societies within which agriculture is practised, the whole stream in our analogy.

All agricultural systems can no longer be viewed as strictly production activities driven primarily by economic pressures. We need to re-establish an awareness of the strong ecological foundation upon which agriculture originally developed and ultimately depends. Too little importance has been given to the 'downstream' effects that are manifest off the farm, either by surrounding natural ecosystems or by human communities. We need an interdisciplinary basis upon which to evaluate these impacts.

In the broader context of sustainability, we must study the environmental background of the agroecosystem, as well as the complex of processes involved in the maintenance of long-term productivity. We must first establish the ecological basis of sustainability in terms of resource use and conservation, including soil, water, genetic resources and air quality. Then we must examine the interactions among the many organisms of the agroecosystem, beginning with interactions at the individual species level and culminating at the ecosystem level as our understanding of the dynamics of the entire system is revealed.

Our understanding of ecosystem-level processes should then integrate the multiple aspects of the social, economic and political systems within which agroecosystems function, making them even more complex systems. Such an integration of ecosystem and social system knowledge about agricultural processes will not only lead to a reduction in synthetic inputs used for maintaining productivity; it will also permit the evaluation of such qualities of agroecosystems as the long-term effects of different input–output strategies, the importance of the environmental services provided by agricultural landscapes, and the relationship between economic and ecological components of sustainable agroecosystem management. By properly selecting and understanding the 'upstream' inputs into agriculture, we can be assured that what we send 'downstream' will promote a sustainable future.

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9

Ecological Basis for Low-Toxicity Integrated Pest Management (IPM) in Rice and Vegetables

Kevin Gallagher, Peter Ooi, Tom Mew, Emer Borromeo, Peter Kenmore and Jan-Willem Ketelaar

Introduction

This chapter focuses on two case studies primarily arising from Asian-based Integrated Pest Management (IPM) programmes. One case study provides an in-depth analysis of well researched and widespread rice-based IPM while the second study focuses on emergent vegetable IPM.

The powerful forces that drive these two systems could not be more different. Rice production is a highly political national security interest that has often justified heavy handed methods in many countries to link high yielding varieties, fertilizers and pesticides to credit or mandatory production packages and led to high direct or indirect subsidies for these inputs. Research, including support for national and international rice research institutes, was well-funded to produce new varieties and basic agronomic and biological data. Vegetable production on the other hand has been led primarily by private sector interests and local markets. Little support for credit, training or research has been provided. High usage of pesticides on vegetables has been the norm due to lack of good knowledge about the crop, poorly adapted varieties and a private sector push for inputs at the local kiosks to tackle exotic pests on exotic varieties in the absence of well-developed management systems.

However, other pressures are now driving change to lower pesticide inputs on both crops. Farmers are more aware of the dangers of some pesticides to their own health and their production environment. The rise of Asian incomes has led to a rise in vegetable consumption that has made consumers more aware of food safety. Cost of inputs is another factor as rice prices fall and input prices climb. More farmers are

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producing vegetables for urban markets, so driving competition to lower input costs as well. Highly variable farm-gate prices for vegetables make farmers' economic decisions to invest in pesticide applications a highly risky business. Research on vegetables is beginning to catch up with rice allowing for better management of pests through prevention and biological controls. IPM programmes in both crops aim to reduce the use of toxic pesticide inputs and the average toxicity of pest management products that are still needed whilst improving profitability of production.

Integrated Pest Management in Rice

This chapter has been prepared to provide a conceptual guide to the recent developments in rice Integrated Pest Management (IPM) within an ecological framework. It is not a 'how to' guide but rather a 'why to' guide for IPM programmes that are based on ecological processes and work towards environmentally friendly and profitable production. We provide a broad overview of IPM practices in rice cultivation including its ecological basis, decision making methods, means of dissemination to farmers and future needs to improve these practices. The breadth of pest problems, including interaction with soil fertility and varietal management are discussed in depth. Although the main focus is on Asian rice cultivation, we also provide examples of rice IPM being applied in other regions.

IPM in rice has been developing in many countries since the early 1960s. However, much of the development was based on older concepts of IPM including intensive scouting and economic thresholds that are not applicable under all conditions (Morse and Buhler, 1997) or for all pests (e.g. diseases, weeds), especially on smallholder farms where the bulk of the world's rice is grown and which are often under a weak or non-existing market economy. During the 1980s and 1990s, important ecological information became available on insect populations that allowed the development of a more comprehensive ecological approach to pest management, as well as greater integration of management practices that went beyond simple scouting and economic threshold levels (Kenmore et al, 1984; Gallagher, 1988; Ooi, 1988; Graf et al, 1992; Barrion and Litsinger, 1994; Rubia et al, 1996; Settle et al, 1996).

Since then, an ecological and economic analytical approach has been taken for management to consider crop development, weather, various pests and their natural enemies. These principles were first articulated in the Indonesian National IPM Programme, but have expanded as IPM programmes have evolved and improved. Currently programmes in Africa and Latin America now use the term Integrated Production and Pest Management (IPPM), and follow these principles: grow a healthy soil and crop; conserve natural enemies; observe fields regularly (soil, water, plant, pests, natural enemies); and farmers should strive to become experts. Within these principles, economic decision making is still the core of rice IPM but incorporates good farming practices as well as active pest problem solving within a production context.

IPM in rice seeks to optimize production and to maximize profits through its various practices. To accomplish this, however, decision making must always consider both the costs of inputs and the ecological ramifications of these inputs. A particular characteristic of Asian rice ecosystems is the presence of a potentially damaging secondary pest, the rice brown planthopper (BPH), *Nilaparvata lugens* (see Box 9.1). This small but mighty insect has in the past occurred in large-scale outbreaks and caused disastrous losses (IRRI, 1979). These outbreaks were pesticide-induced and triggered by pesticide subsidies and policy mismanagement (Kenmore, 1996). BPH is still a localized problem, especially where pesticide overuse and abuse is common, and therefore can be considered as an ecological focal point around which both ecological understanding and management are required for profitable and stable rice cultivation. BPH also becomes the major entry point for all IPM educational programmes since it is always necessary to prevent its outbreak during crop management. Other pests which interact strongly with the

Box 9.1 *The brown planthopper (BPH)*

The brown planthopper (BPH), *Nilaparvata lugens* Stål (Delphacidae, Homoptera), is an insect that has been associated with rice since the crop was grown for food in Asia. This insect is known to survive well only on rice and in evolutionary terms has co-evolved with the rice plant.

Rice fields are invaded by macropterous adults. Upon finding a suitable host, female BPH will lay eggs into the stem and leaf stalks. The egg stage lasts from six to eight days. Nymphs resemble adults except for size and lack of wings. There are five nymphal stages. The complete life cycle lasts 23–25 days. When food is suitable, the next generation of adults are often brachypterous or short winged. Both nymphs and adults prefer to be at the base of rice plants. BPH feeds by removing sap from rice plants, preferably from the phloem.

Usually, populations of BPH are kept low by the action of a wide range of natural enemies indigenous to tropical rice ecosystems in Asia. Outbreaks reported in the tropics during the 1970s were associated with regular use of insecticides. The more effective the insecticide, the faster the resurgence of BPH populations which led to a large-scale dehydration of rice plants, a symptom known as 'hopperburn'. Insecticides removed both BPH as well as their predators and parasitoids. However, eggs laid inside the stem are relatively unharmed by spraying and, when these hatch, BPH nymphs develop in an environment free of predators. In unsprayed fields, the population of BPH did not increase to any significant level, suggesting the importance of biological control. Today, farmers learn about predators by carrying out experiments and when they discover the role of these natural enemies, they are less likely to use insecticides. In Indonesia, Presidential Decree 3/86 provided the framework and support for farmers to understand and conserve natural enemies and this has in turn helped rice fields in Indonesia to be relatively free of BPH in the last ten years. This has coincided with an extensive programme to educate farmers based on the Farmer Field School model.

management of inputs are rice stemborers and the various diseases discussed below.

A major issue when considering IPM decision making is one of paths to rice production intensification. In most cases, intensification means the use of improved high yielding varieties, irrigation, fertilizers and pesticides – as was common in the Green Revolution. However, two approaches to intensification should be considered. The first is input intensification in which it is important to balance an optimal production level against maximizing profits and for which higher inputs can destabilize the production ecosystem. The second route to intensification is one of optimizing all outputs from the rice ecosystem to maximize profits. In many lowland flooded conditions, this may mean systems such as rice–fish or rice–duck that may be more profitable and less risky, yet require lower inputs (and often resulting in lower rice yields). In areas where inputs are expensive, where the ecosystem is too unstable (because of drought, flood) to ensure recovery of input investments, or where rice is not marketed, then such a path to intensification may be more beneficial over time. However, such a system has a different ecology due to the presence of fish or duck, and therefore will involve a different type of IPM decision making.

Ecological Basis of Rice IPM

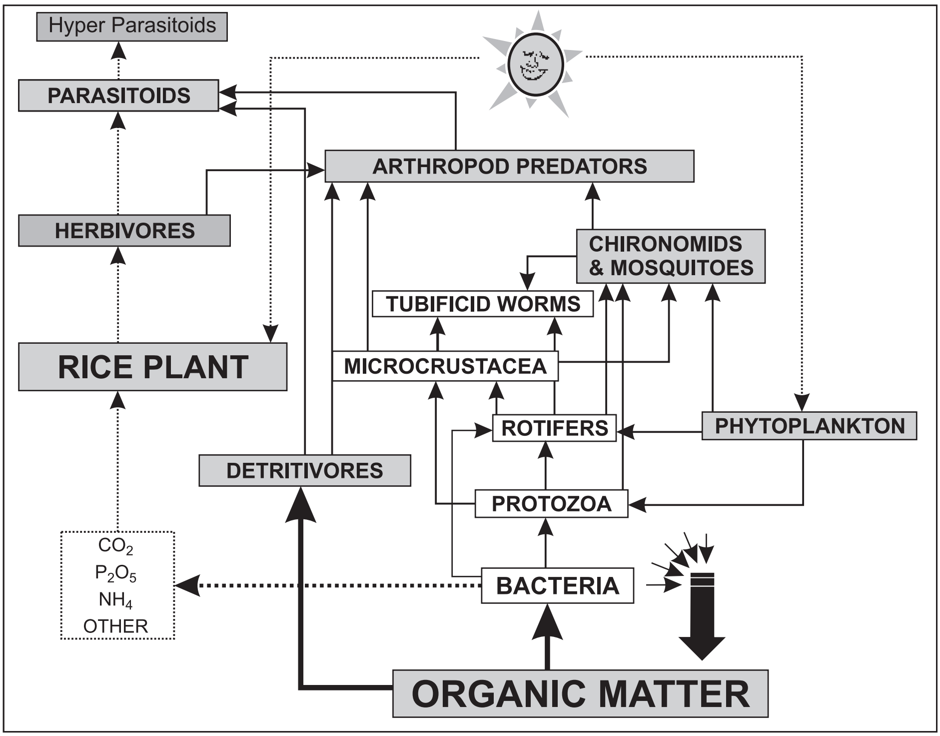
IPM in much of Asian rice is now firmly based on an ecological understanding of the crop and its interaction with soil nutrients and crop varieties. We present below an ecological overview of our current understanding of how the rice ecosystem operates during the development of the crop.

The rice ecosystem in Asia is indigenous to the region and its origins of domestication date back 8000 years to the Yangtze Valley in southern China (Smith, 1995), and more widely some 6000 years ago (Ponting, 1991). Cultivation practices similar to those of today were reached by the 16th century (Hill, 1977). This period of time means that rice plants, pests and natural enemies existed and coevolved together for thousands of generations. Rice ecosystems typically include both a terrestrial and an aquatic environment during the season with regular flooding from irrigation or rainfall. These two dimensions of the rice crop may account for the extremely high biodiversity found in the rice ecosystem and its stability even under intensive continuous cropping – and contrasts with the relative instability of rice production under dryland conditions (Cohen et al, 1994). The irrigated rice systems in Africa, the Americas and Europe also include this aquatic and terrestrial element within which high levels of biodiversity are also found.

Insects

Studies by Settle and farmer research groups in Indonesia (Settle et al, 1996) show that flooding of fields triggers a process of decomposition and development of an aquatic foodweb, which results in large populations of detritus-feeding insects (especially Chironomid and ephydrid flies). These insects emerge onto the water surface and into the rice canopy in large numbers, very early in the growing season, providing critical resources to generalist predator populations long before 'pest' populations have developed (Figure 9.1).

This is quite different from the usual predator–prey models taught in most basic IPM courses and provides a mechanism to suggest that natural levels of pest



Organic matter drives the development of high early-season populations of predators through parallel pathways: (1) microorganisms (zooplankton and phytoplankton) are fed on by filter-feeders (mosquitoes and midges), and (2) organic matter directly feeds detritus-feeding insects (Diptera larvae, Collembola, and some Coleoptera larvae). Each of three pathways dominates at different times of the season: microorganism/filter-feeders early-season; plant/herbivore mid-season; and detritivores post-harvest. The pattern of interaction leads to consistently high populations of generalist predators early in the growing season, and low and stable populations of herbivores later in the season.

Source: After Settle and Whitten, 2000

Figure 9.1 *Hypothesized flow of energy in tropical rice ecosystems* control in tropical irrigated rice ecosystems are far more stable and robust than purely terrestrial agroecosystems. This stability, however, was found to be lower in rice landscapes that are subject to long (more than three month) dry seasons and where rice is planted in large-scale synchronous monocultures, as well as in areas where farmers use pesticides intensively. Increased amounts of organic matter in the soil of irrigated rice fields, by itself a highly valuable practice for sustainable nutrient management, has the additional advantage of boosting both populations of detritus-feeding insects and insect predators, and thereby improving natural levels of pest control (Settle et al, 1996).

A second consideration for rice IPM is the ability of most rice varieties to compensate for damage. The rice plant rapidly develops new leaves and tillers early in the season replacing damaged leaves quickly. The number of tillers produced is always greater than the number of reproductive tillers allowing for some damage of vegetative tillers without affecting reproductive tiller number. The flag leaf contributes to grain filling but the second leaf provides photosynthates as well, while lower leaves are actually a sink that compete with the panicle. Finally, photosynthates appear to move from damaged reproductive tillers to neighbouring tillers so that total hill yield is not as severely impacted as expected when a panicle is damaged by stemborers.

Thus, early season defoliators (such as whorl maggot, case worms and armyworms) cause no yield loss up to approximately 50 per cent defoliation during the first weeks after transplanting (Shepard et al, 1990; Way and Heong, 1994) although higher damage occurs when water control is difficult. As early tillering is also higher than what the plant can ultimately support reproductively, up to 25 per cent vegetative tiller damage by stemborers ('deadhearts') (caused by *Scirpophaga* spp., *Chilo* spp. and *Sesamia* spp.) can be tolerated without significant yield loss (Rubia et al, 1996). Significant damage (above 50 per cent) to the flag leaf by leaffolders (*Cnaphalocrocis mdeinalis* and *Marasmia* spp.) during panicle development and grain filling can cause significant yield loss, although this level of damage is uncommon where natural enemies have been conserved (Graf et al, 1992). Late season stemborer damage (white heads) also causes less damage than previously expected such that up to 5 per cent white heads in most varieties does not cause significant yield loss (Way and Heong, 1994; Rubia et al, 1996).

The conspicuous rice bug (*Leptocorisa oratorius*) is another major target for insecticide applications. However, in a recent study involving farmers and field trainers at 167 locations, van den Berg and Soehardi (2000) have demonstrated that the actual yield loss in the field is much lower than previously assumed. The rice panicle normally leaves part of its grain unfilled as if to anticipate some level of loss (Morrill, 1997). Numerous parasitoids, predators and pathogens present in most rice ecosystems tend to keep these potential pests at low densities (Shepard and Ooi, 1991; Barrion and Litsinger, 1994; Loevinsohn, 1994; Ooi and Shepard, 1994; Matteson, 2000).

Thus, under most situations where natural enemies are conserved, little yield loss is expected from typical levels of insect pests. Up until recently, insecticide applications for early defoliators, dead-hearts and white heads often led to lower natural enemy populations allowing the secondary pest, rice brown planthopper (*Nilaparvata lugens*), to flare up in massive outbreaks (Rombach and Gallagher, 1994). Work by Kenmore et al (1984) and Ooi (1988) clearly showed the secondary pest status of brown planthoppers. Although resistant varieties continue to be released for brown planthopper, the highly migratory sexual populations were found to have high levels of phenotypic variation and be highly adaptable to new varieties. Although wrongly proposed to be 'biotypes', it was found that any population held significant numbers of individuals able to develop on any gene for resistance (Claridge et al, 1982; Sogawa et al, 1984; Gallagher et al, 1994). Huge outbreaks have not reoccurred in areas where pesticide use has dropped due either to changes in policy regulating pesticides in rice or due to educational activities (Box 9.2).

A few minor pests are predictable problems and therefore should be considered for preventive action with natural enemies, resistant varieties, or specific sampling and control. These include black bug (*Scotinophara* spp.), gall midge (*Orseolia oryzae*), and rice hispa (*Dicladispa* spp.) which are consistently found in certain regions; thrips (*Stenchaetothrips biformis*), whereas drought causes leaf-curling that provides them a habitat; armyworms (*Mythimna* spp. and *Spodotera* spp.) in post-drought areas that are attracted by high levels of mobilized nitrogen in the rice plant and panicle cutting armyworms cause extreme damage.

Green leafhoppers (*Nephotettix* spp.) are important vectors of tungro (see below) but by themselves rarely cause yield loss. White-backed planthoppers (*Sogatella* spp.) are closely related to brown planthoppers in terms of population

Box 9.2 *Predators of BPH: hunting spiders*

Predators are the most important natural enemies of BPH. Together with parasitoids and insect pathogens they keep populations of BPH down. An important group of predators commonly found in rice fields is the spiders. Of particular importance are hunting spiders, especially *Lycosa pseudoannulata*. This is often found near the water level, the same area where BPH feed. A lycosid is known to feed on as many as 20 BPH per day. Its voracious appetite makes it a very important natural enemy of BPH. However, there are often questions asked about this predator.

A common one is: What will the spider feed on in the absence of BPH? Like other spiders, *Lycosa* and *Oxyopes* do not depend entirely on BPH for its food. There are many flies in the field that provide the bulk of the food for spiders. Studies in Indonesia have shown the importance of 'neutrals' in supporting a large population of predators in the rice fields. Spiders are found in rice fields before planting and they survive on these 'neutrals'. During the dry season, rice field spiders are known to hide in crevices or in grasses around the field. Like all predators, spiders are very susceptible to insecticides and so sprays or granular applications into the water will destroy these beneficial arthropods, thus allowing BPH to multiply to large numbers.

dynamics and are not usually a major yield-reducing pest. Rice water weevil (*Lissorhoptrus oryzophilus*) introduced from the Caribbean area in North America and North-East Asia is a problem pest requiring intensive sampling (Way et al, 1991) that deserves greater research on its natural enemies. In upland ecosystems, white grub species and population dynamics are not well studied and are difficult to manage. Way et al (1991) provide an overview of insect pest damage dynamics, while Dale (1994) gives an overview of rice insect pest biology.

Diseases

The need to grow more rice under increasingly intensive situations leads to conditions that favour diseases. High planting density, heavy inputs of nitrogen and soil fertility imbalances result in luxuriant crop growth conducive to pathogen invasion and reproduction. This is made worse by genetic uniformity of crop stand that allows unrestricted spread of the disease from one plant to another, together with continuous year-round cropping that allows carry over of the pathogen to succeeding seasons. Reverting to the less intense, low yield agriculture of the past may be out of the question, but a thorough understanding of the ecological conditions associated with the outbreak of specific diseases may lead to sustainable forms of intensification. We briefly describe the specifics for three major diseases of rice, namely, rice blast, sheath blight and rice tungro disease.

Blast (*Pyricularia grisea, Magnaporthe grisea*) occurs throughout the rice world but is usually a problem in areas with a cool, wet climate. It is a recognized problem in upland ecosystems with low-input use and low yield potential, as well as in irrigated ecosystem with high input use and high yield potential (Teng, 1994). Fertilizers and high planting density are known to exacerbate the severity of infection. Plant resistance is widely used to control the disease, but varieties often need to be replaced after a few seasons because pathogens quickly adapt and overcome the varietal resistance. Recent work by IRRI and the Yunnan Agricultural University demonstrated that the disease can be managed effectively through varietal mixtures (Zhu et al, 2000; see Box 9.3).

Sheath blight (*Rhizoctonia solani*) is a problem during warm and humid periods and is also aggravated by dense planting and nitrogen inputs above 100kg/ha^{-1}. No crop plant resistance is known for sheath blight. A number of bacteria (*Pseudomonas* and *Bacillus*) isolated from the rice ecosystem are known to be antagonistic to the pathogen. Foliar application of antagonistic bacteria at maximum tillering stage appeared to effect a progressive reduction of disease in the field over several seasons (Du et al, 2001). Incorporation of straw and other organic matter, with its effect on soil fertility, pH, and possibly on beneficial microorganisms may reduce sheath blight incidence in the long term.

Rice tungro disease, caused by a complex of two viruses transmitted by the green leafhopper (*Nepthettix virescen*), is a destructive disease in some intensively cultivated areas in Asia where planting dates are asynchronous (Chancellor et al, 1999). Overlapping crop seasons provide a continuous availability of host that

Box 9.3 *Diversity defeats disease*

Glutinous rice is highly valued in Yunnan, China, but like many varieties that have been 'defeated' by rice blast, it cannot be grown profitably without multiple foliar applications of fungicide. Rice farmers, guided by a team of experts from IRRI and Yunnan Agricultural University, have successfully controlled rice blast simply by interplanting one row of a susceptible glutinous variety every four or six rows of the more resistant commercial variety. This simple increase in diversity led to a drastic reduction of rice blast (94 per cent) and increase in yield (89 per cent) of the susceptible variety. The mixed population also produced 0.5–0.9 tonnes more rice per ha than their corresponding monocultures, indicating high ecological efficiency. By the year 2001, this practice has spread in over 100,000ha of rice in Yunnan, and is being tried by other provinces.

Varietal diversity creates an entirely different condition that affects host pathogen interaction. To begin with, a more disease-resistant crop, interplanted with a susceptible crop, can act as a physical barrier to the spread of disease spores. Second, with more than one crop variety, there would also be a more diverse array of pathogen population, possibly resulting in induced resistance and a complex interaction that prevents the dominance by a single virulent strain of the pathogen. Finally, interplanting changes the microclimate, which may be less favourable to the pathogen.

enables year round survival of the virus and the vector. Controlling the vector population with insecticide does not always result in tungro control. Synchronous planting effectively puts the disease at manageable levels. When and where planting synchrony is not possible, resistant varieties are recommended. In addition to varieties with a certain degree of resistance to the vector, varieties highly resistant to the virus itself became available recently. Farmers should also employ crop or varietal rotation, and rogue intensively.

Fungicidal control of blast and sheath blight is increasing in many intensified rice areas. It is extremely important that these fungicides be carefully screened not only for efficacy as fungicides but also for their impact on natural enemies in the rice ecosystem. One example is the release of iprobenfos as a fungicide for blast control. Iprobenfos is an organophosphate that was originally developed for brown planthopper control and is highly toxic to natural enemies. Its use in the rice ecosystem is likely to cause ecological destabilization and consequent outbreaks of brown planthopper. Fungicides should also be carefully screened for their impact on fish, both to avoid environmental damage in aquatic systems and to avoid damage to rice–fish production.

In general, clean and high quality seed with resistance to locally known diseases is the first step in rice IPM for diseases. An appropriate diversification strategy (varietal mixture, varietal rotation, varietal deployment, crop rotation) should counter the capacity of pathogens to adapt quickly to the resistance of the host. Management of organic matter has to be geared not only towards achieving balanced fertility but also in enhancing the population of beneficial microorganisms.

Farmers in Korea who face heavy disease pressure can learn to predict potential outbreaks using educational activities that combine various weather and agronomic input parameters with disease outcomes. Computer-based models are also being commercially sold to predict disease potential based on meteorological monitoring. With increasing nitrogen applications, however, greater disease incidence can also be expected.

Weeds

The origin of puddling for lowland rice cultivation is thought to have been invented to create an anaerobic environment that effectively kills several weeds including weedy and red rice. In most IPM programmes for lowland rice, weed management has therefore been closely considered part of agronomic practices during puddling and later during aeration of the soil with cultivators. At least two hand weedings are necessary in most crops, and considered in many countries economically viable due to low labour cost or community obligations to the land-less, who are then allowed to participate in the harvest. With rising labour costs, decreasing labour availability and more effective herbicides, this situation is rapidly changing to one of using one or two applications of pre- or post-emergence herbicides. As in the case of fungicides, it is critical that these herbicides do not upset natural enemies, fish or other beneficial/non-target organisms in the aquatic ecosystem including microorganisms (see Figure 9.1). In the case of upland rice, similar changes are rapidly occurring although better dry land cultivators are already being developed for inter-row cultivation as an alternative to herbicides.

Non-herbicide but low labour weed management methods are also emerging from the organic agriculture sector. The International Association of Rice Duck Farming in Asia supports research and exchanges among mostly organic farmers. In rice–duck farming, a special breed of duck is allowed to walk through the field looking for food that is either broadcast or naturally occurring, and the action of walking up and down the rows is sufficient to control most weeds. In Thailand, mungbean and rice are broadcast together with some straw covering in rainfed rice fields. When the rains come, both crops germinate. If there is abundant rain, the mungbean will eventually die and become part of the mulch, but if the rain is insufficient for the rice then the mungbean will be harvested.

No-till, no-herbicide combined with ground cover from winter barley straw or Chinese milky-vetch is being used in South Korea in both conventional and organic systems. Organic farmers in California use a water management system in which there is a period of deep (30cm) flooding followed by complete drying – the rice can take the changes but young weeds cannot. A widely adopted method in Central Thailand involves growing rice from ratoons. After harvest the stubble is covered with straw and then irrigated which allows the rice plant to emerge. This method not only controls weeds effectively but also increases organic matter and requires no tilling.

However, for the majority of rice cultivation, labour saving often means moving towards direct seeded rice and thus more weed problems. Red rice (weedy off-type of rice) is already the key pest in most of the Latin American direct seeded rice production areas. It seems clear that more direct seeding will lead to more herbicide use in rice production. Yet herbicide resistance is also sure to eventually emerge and there are obvious health and environmental costs associated with some herbicides. Thus it is important that IPM for rice weeds be improved and considered in the broadest terms (e.g. promoting modern rice varieties that are red in colour among consumers may be part of the solution to red rice problems). Crop rotations are feasible in only some areas, while simple line sowers or tractor sowing in rows combined with manual or tractor cultivation may provide some solutions for lowland and upland rice.

Genetically modified herbicide-resistant rice will eventually be on the market, but Asian consumer preference may not favour these varieties. However, the resulting increase in herbicide use could have obvious adverse effects on the aquatic systems that are associated with most rice production. In addition, a major problem of herbicide resistant rice is the possibility of the transfer of gene resistance to weedy rice, though such transfers would not occur to wild grass species. Use of herbicide resistant rice in monocropping could also create, in the long term, serious problems of glyphosate resistance in weed species previously susceptible to the herbicide. The ecosystem level interactions of herbicide resistant rice will need careful assessment prior to their use.

Community pests

Insects, diseases (with the exception of tungro virus) and weeds in rice ecosystems are generally managed with decisions on individual farms or plots. However, some pests, particularly rats, snails and birds, require community-level planning and action. Management of these pests requires facilitation of community organizations not generally supported by extension services with the possible exception of some multi-purpose cooperatives and water-user associations.

Numerous species of rats occur in rice fields and can cause considerable damage. Rats migrate from permanent habitats to rice fields as food supply changes throughout a yearly cycle, with rice plants most preferred after the panicles have emerged. Some natural enemies of rats, particularly snakes, are harmed by pesticides and often killed by farmers, thus resulting in more rats. The most effective management strategies are to ensure baits are appropriate to the species present, and then carry out continuous trapping along feeding routes, fumigation or digging of rat holes, and establishing early season bait stations using second generation anticoagulant baits (although more toxic zinc phosphide and repackaged and unlabelled aldicarb is still commonly seen but strongly discouraged in most countries due to the deaths of children and small livestock). Community programmes can include educational activities on rat biology and behaviour (Buckle, 1988), and an emphasis on action during the early season vegetative stage is considered the key to rat management (Buckle and Smith, 1994; Leung et al, 1999). An innovative owl habitat programme in Malaysia has been successful in increasing owl populations to control rats in rice and plantation crops.

The Golden apple snail, *Pomacea canaliculata*, was originally introduced to rice growing areas as an income generating activity for a caviar look-alike given its brightly pink coloured egg clusters. It has since become widespread from Japan to Indonesia and is now one of the most damaging pests of rice. It was introduced without appropriate tests in any country even though it was on the quarantine lists of several countries. The snail feeds on vegetation in aquatic environments, including newly transplanted rice seedlings up to about 25 days old when the stems become too hard. With no natural enemies and having highly mobile early stages that flow with irrigation water, the golden snail spreads rapidly. Pesticides are often used before transplanting or direct seeding, mainly highly toxic products such as endosulfan, organo-tin products and metaldehyde. These products have serious health implications and also cause the death of potential fish predators and natural enemies early in the season (Halwart, 1994). The use of bamboo screens as inlets to fields to inhibit snail movement is reported as the first line of snail defence. Draining fields that have several shallow ditches where the snails will congregate allows for faster collection or eases the herding of ducks into fields to eat the snails. In Vietnam, snails are reported to be collected, chopped, cooked and used as fish food to such an extent that they are now a declining problem.

Birds can be very damaging especially when occurring in large flocks. The Red-billed Quelea, *Quelea quelea*, in sub-Saharan Africa and various species in Asia are known as consistent problems in rice ecosystems. In most Asian countries and in Chad, netting is used to trap large numbers of birds for sale as food. Mass nest destruction is also possible for some species. In Asia, these methods have effectively reduced pest bird populations to very low numbers. In Africa, the capture method may bring benefits to local people in terms of income or a good protein addition to the diet, but the impact on pest bird populations has been small. During the ripening period in North-East Asia, some fields are protected by being covered with bird nets. Reflective ribbons or used video or cassette tape are widely used to scare birds in Asia. Sound cannons and owl or hawk look-alikes are also used in many countries, though some birds become quickly habituated to mechanical devices. Use of poisoned baits and the destruction of bird nesting habitat are discouraged both because they are seldom effective and also because of the potential negative effect on non-target species in adjacent aquatic environments.

Does IPM Work for Rice Farmers?

Although there is a large amount of grey literature (see www.communityipm.org) related to rice IPM impact among farmers, there is little peer-reviewed published data. This is in part a reflection of the financial and technical difficulty of conducting these studies. Longitudinal studies in agriculture are notoriously difficult due to seasonal changes. Latitudinal studies (comparisons across sites) are also difficult due to the fact that finding an identical IPM and non-IPM control is rarely possible given the diversity of ecological and social conditions. Nonetheless, such evidence as does exist indicates considerable benefits for rice IPM farmers.

The first, and perhaps strongest indicator, is the greatly reduced incidence of brown planthopper. Wide area outbreaks accompanied with massive losses have no longer been experienced during the past 15 years since IPM programmes have become widely implemented in both policy and field training. In most cases, changes in policy involved the removal of pesticide subsidies, restrictions on outbreak-causing pesticides, and investment in biological research and educational programmes for decision makers, extension workers and farmers. These policy changes most often came about as a result of successful small-scale field trials. The FAO Inter-Country Programme for Rice IPM in South and South-East Asia, headed by Peter Kenmore, brought policy makers in contact with researchers and farmers who could explain from their own experience the ecological basis of farming with IPM methods. The banning of 57 pesticides and removal of pesticide subsidies known to cause brown planthopper outbreaks in 1987 in Indonesia by the former President Suharto came about after cabinet officials were brought into a dialogue with both senior Indonesian and IRRI scientists and farmer groups who had shown the outbreak effects of the pesticides and their ability to produce high rice yields without these pesticides (Eveleens, 2004).

The second indication comes from case study literature (FAO, 1998). Table 9.1 gives a typical result found across hundreds of communities surveyed in rice IPM programmes. This shows the key changes in practices, especially the common outcome of investing less in pesticides and more in fertilizers (including P and K). Other large-scale studies provide similar data, although a recent study in Vietnam notes an increase in the use of fungicides. The authors have noted that with higher levels of fertilizers (as would be found in Vietnam) such increases in fungicide are predictable. This data also reveal the multidisciplinary aspect of rice IPM in that it encourages farmers to look beyond the pest complex into the multiple parameters for achieving a profitable high yielding crop.

Getting IPM into the Hands of Farmers

'IPM is not for farmers but is by farmers' is often noted in IPM programmes. Getting IPM into the hands of farmers, however, is not always easy. Several methods have been developed with various levels of information and completeness. Most agricultural extension services now recognize the importance of natural enemies and are quick to point out the need to conserve them, even though their co-promotion of various insecticides, fungicides and herbicides is at odds with this apparent awareness of natural enemies. Work by Heong and others from the Rice IPM Network (Heong et al, 1998; Heong and Escalada, 1999; Huan et al, 1999)

Table 9.1 *Financial analysis of ten IPM field school alumni and ten non-alumni farms from impact assessment in Lalabata, Soppeng, Ujung Pandang, South Sulawesi, Indonesia*

	IPM Alumni (Rp. 000/ha^{-1})	*Non-alumni (Rp. 000/ha^{-1})*
Ploughing	105	84
Planting	113	102
Weeding	49	47
Harvest	67	59
Seeds	18	21
Urea	80	96
SP36	30	12
KCl	25	12
ZA	41	0
Pesticides	7	28
Irrigation	25	25
Total costs	560	501
Yield (kg/ha^{-1})	6633	5915
Returns	2786	2485
Income	2226	1983
Difference	+243	

Note: Farm gate rice price Rp. 420/kg.

Source: FAO, 1998

has developed interesting radio messages to get the word out on a large scale that early spraying of insecticides during the first 40 days of the crop is not only unnecessary but increases the risk of higher pest populations later in the crop. The radio messages are accompanied by field-based plant compensation participatory research groups in many cases (Heong and Escalada, 1998). This programme has been effective in increasing awareness of the adverse effects of insecticides on natural enemies and the role of plant compensation in recovering without yield loss from early season pest damage and has resulted in reduced early insecticide sprays.

Study groups of various types are now common in many rice systems. They are reported from organic agriculture, rice–duck groups, Australian rice farmer associations and many others. The FAO Community IPM Programme in Asia (Matteson et al, 1994) has promoted study groups now called 'Farmer Field Schools' under which structured learning exercises in fields ('schools without walls') are used to study both ecosystem level dynamics transferable to other crops (predation, parasitism, plant compensation) as well as specific rice IPM methods. Already, more than 1.5 million farmers have graduated from one or more season-long Field Schools in Asia over the past decade with good cost-effectiveness as an extension methodology (Ooi et al, 2001).

Community-based study groups, study circles, field schools and other approaches are now being integrated with wider community-based organizations, such as IPM clubs, water-user groups, women's organizations and local farmer unions (Pretty and Ward, 2001). With the large-scale training and visit style extension programmes generally being phased out in most countries, it will be necessary for local communities to become organized in ways in which they can increasingly cover their own costs for experts. Primary school programmes on IPM are also emerging in Thailand, Cambodia, Philippines and other countries as part of environmental education curriculum related to Asian rice-culture. Such programmes as Farmer Field Schools in many countries or Landcare in Australia and the Philippines are providing innovative models in community-based study and action.

The future of IPM in rice in Asia, if not globally, should see the phasing out of all Class Ia, Ib and II products, while phasing in production methods that allow for whole ecosystem approaches. Organic pest management (OPM) alongside the rapid expansion of certified organic rice production is certainly an area fertile for research and training in addition to modernized IPM approaches.

Vegetable Production in Tropical Asia

Vegetables are an important part of the diet, adding valuable nutrients that would otherwise be insufficiently available in staples such as rice or maize. New production areas are continuously being opened up, sometimes at the expense of rice land, to meet the demands for vegetables, particularly crucifers, carrots, potatoes, tomatoes and beans. Many vegetable crops perform best under cool temperatures found in higher altitudes, but, increasingly, vegetable production is expanding into the lowlands with the release of new heat-tolerant varieties mainly bred in Asia. But the achievement of good yields, particularly in the warm humid lowlands, is often constrained by pests and diseases. Most vegetables are heavily sprayed and in many places poor horticultural practices exacerbate these crop production constraints. In general, a lack of skills among vegetable producers and limited or no access to sources of information on new and ecologically sound crop production practices provide a clear rationale for why much of intensified vegetable production in Asia is currently facing serious problems.

Problems Associated with the Indiscriminate use of Synthetic Pesticides

The indiscriminate use of synthetic pesticides in intensified vegetable production in tropical Asia is a serious problem (Shepard et al, 2001). Pest problems in tropical vegetable production occur frequently and are often acute. Yields are highly

Table 9.2 *Average number of pesticide applications per season for selected vegetable crops in Cambodia*

	Cucumber	*Yard long bean*	*Mustard*	*Cabbage*	*Radish*
Number of pesticide applications per crop cycle	7.5	9.1	5.7	12.1	10.0

Source: Adapted from van Duuren, 2003

variable while farm gate prices vary considerably on both a daily and seasonal basis. Compared with rice, the riskiness of vegetable production provides a stimulus for farmers to rely on preventive pesticide applications. For some vegetable crops the average frequency of application of chemical pesticides is 10–20 times per season (see Table 9.2), with up to 80 applications per season for *brinjal* (eggplant) production in parts of South Asia (e.g. in Bangladesh).

The application of cocktails of pesticides by vegetable farmers is also a common phenomenon, particularly in Cambodia and Indonesia. Farmers mix insecticides with fungicides and herbicides in an effort to make them more effective. These cocktails commonly include banned or restricted, and often highly toxic, insecticides such as DDT, endosulfan, chlordane, sodium cyanide, methyl parathion, mevinphos, methamidophos or monocrotophos.

A recent survey among 332 vegetable producers in Cambodia indicated that 55 per cent of farmers interviewed were using WHO Class Ia pesticides. This figure increases by another 18 per cent when farmers who are using Class Ib pesticides are included. Thus, an alarming 73 per cent of interviewed farmers were frequently handling highly and extremely toxic pesticides under conditions that are far from those that can possibly be considered safe (see Table 9.3). The health hazards to farmers and their families are serious (Murphy et al, 1999; Sodavy et al, 2000).

Table 9.3 *Proportion of vegetable farmers (n = 360) using protective clothing during pesticide applications*

Clothing and protective gear	*Proportion of farmers using each element during application (%)*
Long sleeved shirts and long pants	82
Cotton mask to protect from inhalation	64
Traditional scarf wrapped around head	52
Boots	38
Gloves	8
Raincoat	3
Protective glasses	2
Ordinary clothing	8

Source: Adapted from van Duuren, 2003

In Cambodia and Laos, labelling of pesticide products is often inappropriate as labels are usually in foreign languages (Thai, Vietnamese). This situation is aggravated by high illiteracy rates in the rural population. Original products are often repackaged and contain no label at all (EJF, 2001). For example, a recent study conducted in Cambodia revealed that only 8 of 77 pesticide traders said they could read foreign labels on pesticides they sold, whilst 97.5 per cent of the pesticides were labelled in a foreign language (CEDAC, 2000). The extensive use of synthetic pesticides results in a range of unsustainable production practices arising from undesirable externalities. The frequent applications of pesticides most often causes resurgence of pest populations because of the destruction of natural enemies. Resistance of target pests against pesticides has become a serious problem for many important vegetable pest problems, such as diamond back moth (*Plutella xylostella*) on crucifers and fruit and shoot borer (*Leucinodes orbonalis*) on eggplants.

However, greater awareness among consumers in urban communities of the dangers of pesticide residues on vegetables has created a growing demand for vegetables free of residues. Governments in many developed Asian countries have now established maximum residue levels (MRL) regulations for pesticides on imported vegetables. Clearly, the consequences of international trade restrictions related to residues of toxic pesticides on vegetable produce can no longer be ignored. Nonetheless, vegetable production in tropical and subtropical Asia remains in a 'crisis phase' (Lim and Di, 1989; Shepard and Shepard, 1997), requiring urgent attention to safeguard the production of healthy food and producers' livelihoods across Asia.

Vegetable IPM: Ecosystem Considerations and the Need for 'Informed Intervention'

What is it that drives the frequent use of pesticides in intensified vegetable production in most of Asia? The main factors seem to be the high risk of crop losses, the acute occurrence of serious crop pests, and the heavy promotion of pesticide use by the private sector. In addition, the low level of ecological literacy and wider low level of education of farmers, particularly in a country like war-ravaged Cambodia, further explains the rampant use of pesticides. However, it is important to understand that there are some major differences between the need for human intervention in ecosystem management when comparing vegetables to rice in tropical Asia.

While many locally consumed vegetables are native to tropical Asia, most vegetables produced in Asia for local consumption and for market supply are exotics. Many popular cash crops such as tomatoes, crucifers, potatoes were relatively recently introduced to Asia from temperate regions. Similarly, many important pest and disease problems are exotic, such as the diamond back moth, which was introduced from Europe into Asia without its naturally existing complex of natural enemies. If not swiftly and adequately managed, crop protection problems can lead to serious cosmetic damage and total crop failure. Vegetable ecosystems are much less stable compared with paddy rice ecosystems

Any rice FFS alumni farmer would be able to explain and demonstrate in their field that there are several highly effective predators and/or parasitoids indigenously available as integral components of a well-functioning rice ecosystem. As a result, pest populations are well regulated and rarely reach critically damaging levels. Management interventions are therefore rarely needed. In fact, human intervention with applications of pesticides causes more problems than it solves. The basic message that IPM Farmer Field Schools spread focuses on ensuring that farmers do not intervene when pest problems occur, and rather let nature play out its well-regulated population dynamic games. The IPM management strategy to be employed in Asian rice production can thus be characterized with 'informed non-intervention'.

But the situation is very different in vegetable ecosystems in tropical Asia, as these are designed to prevent and manage pest and disease problems from causing serious crop loss. The crop protection strategy therefore employed in intensified tropical vegetable production is based on informed (and proactive and preventive) intervention (Whitten and Ketelaar, 2003).

Making Vegetable IPM Work: The Need for Farmers to Become IPM Experts

With the urgent need to address problems associated with the indiscriminate use of pesticides, the FAO Inter-Country Programme for Vegetable IPM in South and South-East Asia has carried out applied research, extension and farmer education activities to promote and support IPM in vegetables. Based on impact assessment of farmer training work conducted by this FAO Programme and its associated National IPM Programmes in a variety of crops in several Asian countries, IPM trained vegetable farmers can now avoid excessive and inappropriate use of pesticides (Larsen, 2001; Lim and Ooi, 2003).

Farmers who undergo season-long discovery-based training in Farmer Field Schools become ecologically literate, and so can understand much better how ecosystems function and what is the likely impact of their management decisions. By being better able to identify field problems and assess their potential impact on yields, farmers can considerably reduce the use of pesticides in vegetable production and limit any remaining applications to those situations where human intervention is necessary. As a result of FFS training, farmers can also make better decisions on which pesticides to purchase, how and when to apply them, and how to avoid cocktail formulations.

These IPM trained farmers are then better placed to access new information and to adapt and adopt novel options that reduce further dependency on pesticides. The potential for better understanding and improved access of farmers to biocontrol interventions, such as the employment of viral and fungal pathogens and the introduction of parasitoids for pest management, is considerable. But it requires proactive action from a range of different stakeholders (research, private sector, extension workers and farmers) so as to ensure that functional biocontrol can reach its full potential. This would further assist the process of eliminating toxic products from vegetable production.

In Cambodia, the National IPM Programme, with FAO support, is currently implementing a FFS-based farmer training programme in several major vegetable growing areas in the country. Farmers who have undergone training are now running training for other farmers and are actively experimenting with growing crops with lower inputs of pesticides. When interventions are indeed needed, farmers now prefer to resort to biocontrol, using the biopesticide, *Bacillus thuringiensis*, which has no adverse effects on farmers' and consumers' health.

Local NGOs, such as Srer Khmer, are actively supporting a self-sustained and multiple season IPM learning process and are facilitating the mobilization of IPM farmer groups and their associations. IPM farmer clubs are also increasingly becoming interested in embarking on the production of organic vegetables for the local niche markets. With the active support from the Government and NGOs, formal education efforts are underway to give school children access to ecosystem education, using the discovery-based learning methodologies employed in the FFS for adults. The hope is that this will lead to greater ecological literacy among Cambodia's youth and future farmers.

Future Needs in Rice and Vegetable IPM

There is still much room for improvement for IPM. Indeed, the ecological view of rice and vegetables presented here must be given greater support by international and national scientists and policy makers to widen economic and ecosystems benefits already being realized by some farmers. A new CD-ROM produced by IRRI is beginning to bring together basic rice information in an accessible format, while the World Vegetable Centre in Taiwan has developed a web-based study programme. Both programmes could be helpful in training extension staff but still remain distant from farmers. Major other challenges remain. Post-harvest pests are still a problem and deserve greater research on non-toxic management methods, and environmentally friendly methods of controls for all types of pests, especially weeds and fungal pathogens, are required to reduce the pressure on the natural resources.

Some countries are calling for major changes. South Korea has banned pesticide use in Seoul's watersheds and is promoting organic agricultural investments to ensure both clean water and high levels of production. Other communities are moving away from grain maximization to diversification such as rice–fish–vegetable culture as a response. This is expected to increase as demand for more profitable non-grain products increases and nitrogen use is reduced to lower environmental impacts and incidence of expensive-to-control fungal pathogens. However, IPM development is required in more countries. These programmes should ensure that educational systems (both formal and non-formal) are responding to the future needs of reducing the environmental impact of agriculture while improving yields. IPM is clearly a major aspect of this education.

There is a need to phase in new plant protection methods and products including subsidizing commercialization of locally produced products such as pheromones, attractants, natural enemies, pest-exclusion netting (for insects and birds), high-quality seed, improved disease resistance and balanced soil fertility products. High foreign exchange costs for imported pesticides and increasing consumer awareness of the social costs arising from pesticides and inorganic fertilizers can be expected to drive rice IPM system development. The trend will be towards lower impact and local production of environmentally friendly pest management. A significant redefinition of IPM to exclude Class I and most Class II products could be a most important step to revitalize private sector, research and extension IPM activities.

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10

The Farm as Natural Habitat

Dana L. Jackson

'We should be having our summer board meeting on a farm. It's really beautiful at my place now.' When Dan French brought this up at the annual meeting of the Land Stewardship Project's board of directors, everyone nodded in agreement. Why didn't we think about scheduling the meeting there? I had spent a few days at the French farm several summers ago, sitting under a tent listening to instructors in the holistic management course held there and looking at Muriel's flower garden and the black-and-white dairy cows in the pasture beyond. A light breeze brought us the fragrance of green alfalfa from the barn where Dan's son was unloading bales. The class walked down to the creek, where we talked about the water cycle and how to judge water quality by observing the kinds of insects and fish in the water. The gravel on the creek bottom sparkled in the clear water. There was a flurry of birds and birdsong in the taller grass of a pasture section that hadn't been grazed for awhile.

When you drive up to the French farm, it looks like an interesting place, with its barns and outbuildings, vegetable and flower gardens, and shady picnic area. It doesn't look like those farmsteads one often sees in the Corn Belt, where the house and a machinery shed or two seem to just stick up out of a corn field, as if the owners had planted every inch they could on the place. Actually, if you drive on Interstate 35 between Saint Paul and Des Moines, you do not even see many houses. The landscape in July seems to be covered just with corn, a seemingly endless monotony of green stalks broken occasionally by shorter bushy soybeans.

It is hard to imagine what it must have looked like when Europeans first settled the Midwest, when it was a wilderness covered with prairie, forests, clear streams, and herds of buffalo. Too quickly it became dominated by agricultural uses interrupted by a few patches of prairie or woods around lakes or rivers that harboured remnants of natural habitat. Some prairie plants survived in pastures and meadows until they were replaced by fields of corn and soybeans in the last part of the 20th century. Then animals were moved into barns and feedlots, fences came down, and habitat edges disappeared. It only took about 150 years to reduce biological diversity on this landscape to a numbing sameness.

It is no surprise that people passionate about wildlife and the preservation of natural habitats have concentrated on protecting other places, those dramatic expanses of land where more of the original landscape remains, such as the Boundary Waters Canoe Area in northern Minnesota, the rugged mountains of Colorado and Montana, and roadless areas in Alaska. Such conservationists have accepted the agricultural Midwest, especially the Corn Belt, as a sacrifice area, like an open pit iron mine, or an oil field, where we mine the rich soil and create toxic wastes to extract basic raw materials. But the environmental impacts of this kind of mining are not confined to farming country. No nature preserves within its watersheds or wildlife area downstream on the Mississippi River can be adequately protected from farming practices that simplify ecosystems to a few manageable species and replace ecosystem services with industrial processes.

People who live in rural areas or urban residents who drive through them may not know that they are seeing a biologically impoverished landscape, because they have no knowledge of its diversity before modern agriculture. Others may know or imagine what the land looked like with different kinds of crops, meadows and livestock in pastures, but they accept its simplification because they are convinced that the main trends in agriculture cannot be overcome. Agribusiness has successfully persuaded farmers, politicians, civic leaders and even conservationists to believe that agricultural modernization leads to specialization and industrialization, and that financially viable alternatives are unavailable even though such modernization reduces the rural quality of life and harms the environment.

In this chapter, I will introduce an alternative vision for agriculture that defies the trends considered inevitable. It is a vision inspired by Aldo Leopold's writing that farming and natural areas should be interspersed, not separated, and by the farmer-members of the Land Stewardship Project, whose ways of managing farms have created a natural habitat for them, for their crops and livestock, and for the native plants and animals of the area. I will also describe two sustainable farming practices that currently are improving biological diversity on rural landscapes and showing the real possibility of this vision. Let us look at the practices of mainstream industrial farming that render the countryside an ecological sacrifice zone.

Rural Lands as Industrial Zones

The loss of biological diversity was not the only environmental consequence of creating the Corn Belt. Soil erosion, depletion of water resources, contamination of groundwater and surface water from fertilizers and pesticides (Soule and Piper, 1991), and a steady silt load in rivers are some of the consequences of so much tilled land. The sediment load in the Minnesota River at Mankato is equal to a ten-ton dump truck load moving by approximately every five and a half minutes (Minnesota Pollution Control Agency, 1994).

The most serious environmental consequences are yet to come because of the growing consolidation in the livestock industry fuelled by the abundance of cheap corn and soybeans. Each year an increasing number of poultry and hogs raised in the Corn Belt are not dispersed across the countryside on independent farms but are instead concentrated in large operations. Hundreds of thousands of chickens and tens of thousands of hogs are confined in buildings, creating huge quantities of manure that pose serious environmental risks to ground and surface water. Hydrogen sulfide fumes in the stench emitted from the operations have sickened neighbours. People do not want to live close to these hog factories or visit relatives close to hog factories. The once rich prairies that became bucolic communities are now industrial zones, suitable for 'neither man nor beast'.

Dairy farmers also feed the bounteous harvest of the Corn Belt to cattle confined in barns and milked three times a day. Dairy operations with 1000 to 2000 cows are replacing traditional family-sized farms with 100 or fewer cows. They manage large quantities of manure the same way as hog factories do and present the same risks to water quality. Travellers through Wisconsin's wooded hill lands graced with small dairy farms in the valleys may be unaware of how this landscape will change if consolidation continues in the dairy industry and four dairy farmers go out of business each day in the state as they did between 1992 and 1997 (USDA, 1997). Where large-scale dairies replace small ones, the scenes of black-and-white cows grazing on green pastures and moving in line to and from red barns are being replaced by fields of corn and soybeans with nary a cow in sight.

Factory livestock operations have popped up like mushrooms across the entire Midwest and Great Plains. They have also grown rapidly in southern states and are emerging everywhere state laws are weak and local communities naively believe the industry's forecasts for economic development. California led the way with its 1000 cow dairies and became the leading milk producer in the country; as a result, departments of agriculture in traditional dairy states are promoting California-style dairying. Agricultural economists encourage farmers to expand their operations to be efficient and convince them that all dairy cows and pigs, like poultry, are going to be raised in large-scale confinement operations in the future. It is inevitable.

This mantra of 'it's inevitable' is happily chanted by the corporate processors of pork that benefit from large supplies of cheap hogs, and, sadly, this mantra is repeated by many farmers. Some of them borrowed heavily to expand and build hog confinement buildings, and when pork prices plunged to an historic low in the 1990s, they went bankrupt. The huge packing plants that encouraged industrial production prospered and consolidated into even larger corporations through mergers (Heffernan, 1999).

We are seeing rural landscapes all across the US changing for the worse because farmers believe that further industrialization in livestock agriculture is inevitable and that they must 'get big or get out'. Some farmers incur staggering debt to increase the size of their operations, some form family corporations to share the costs of expansion, others invest in new buildings and technology to become contract producers for corporations, and some just leave farming and sell out to neighbours who want to expand. A house in the country isn't so romantic any more, because it might very well be within odour range of one of these hog expansions.

Hay meadows and pastures with wildflowers and grassland birds are few and far between, and many streams running through fields have been cleared of trees and wildlife. If a family cannot earn a living on the land, and it is not a beautiful or healthful place to live, they might as well move to town. The land serves utilitarian purposes only, sacrificing natural values that once made it a home, not only for humans, but also for all kinds of creatures.

The disappearance of diversity in farming country has occurred steadily, mostly without notice or comment. Politicians and policy makers, the US Department of Agriculture, land grant universities, and many farmers and rural people accept the loss of biological diversity on the land as a necessary cost of efficient high production. There is some nostalgia in older people for a favourite fishing or swimming hole on the creek of the farm on which they grew up, but farming is a business and you cannot be sentimental about it. Most travellers are not aware that many of the monotonous fields they see along the highways harboured wildlife in prairie pastures and hayfields as recently as the 1960s. They only know that if they want to see woods and prairies and wildlife, they must head for a publicly owned park or wildlife area where agriculture is not practised.

Aldo Leopold and a Different Vision for Agriculture

Aldo Leopold, the Midwest's most famous conservationist, disapproved of the separation of natural areas from farming. To him it did not make sense to protect forests in a special area and accept the absence of trees on agricultural land, when the farm was then left without the conservation benefit of erosion control and windbreaks. 'Doesn't conservation imply a certain interspersion of land uses, a certain pepper-and-salt pattern in the warp and woof of the land use fabric?' he asked (Leopold, 1991). Leopold believed that conservation efforts on certain parts of the land would fail if other parts were ruthlessly exploited. He wrote in the essay 'Round River':

> Conservation is a state of harmony between men and land. By land is meant all of the things on, over, or in the earth. Harmony with land is like harmony with a friend; you cannot cherish his right hand and chop off his left. That is to say, you cannot love game and hate predators; you cannot conserve the waters and waste the ranges; you cannot build the forest and mine the farm. The land is one organism. (Leopold, 1966)

Although Leopold knew that agriculture was becoming more industrialized and wrote about the dangers of a farm becoming a factory, he could not have imagined the enormous livestock factories in production today. The transformation of so many meadows, prairies and wetlands into corn, beans and hogs in Iowa, the state of his birth, and conversion of family-sized dairy farms into milk factories and corn fields in his adopted state of Wisconsin would astonish and grieve him. However, if someone told him about the zone of hypoxia in the Gulf of Mexico, 7000 square miles depleted of marine life because of excess nutrients flowing down the Mississippi River from the Corn Belt, I doubt if he would be surprised.

It is understandable that people accept these trends as the destiny of agriculture if they cannot clearly see alternatives. But there is an alternative – another trend – that could produce a landscape of farms which are natural habitats rather than ecological sacrifice areas.

A strong minority of modern farmers, like Dan and Muriel French, have not turned their farms into factories nor abandoned their chosen profession but are instead leading agriculture in an entirely different direction. Their creative initiatives to make farming more economically sound and environmentally friendly are producing benefits for them, for society at large and for the land. The trends of these models are toward independent farms supporting families and communities while restoring biological diversity and health to the land.

Using an ecological approach to management decisions, these farmers are restoring a relationship between farming and the natural world that improves the sustainability of both. This relationship makes the farm a natural habitat. It is a natural habitat for humans in that it is a healthful and aesthetic place to live and earn a living. The farm is a natural habitat for the crops and livestock because they are able to use ecosystem services for fertility and pest control rather than fossil fuel and man-made chemicals. And the farm is a natural habitat for native plants and animals, a refuge that encourages biological diversity along streams, in pastures and along uncultivated edges.

Farming Practices for Natural Habitat

Farmers themselves do not talk about turning their farms into natural habitats. It happens as a result of the way that they choose to farm. Many farmers became interested in changing their practices in the 1980s, particularly during a period of low prices, high production costs and minuscule profits. A number of newly formed farming organizations around the country helped them lower their use of purchased inputs, such as chemical fertilizer and pesticides, and develop more environmentally friendly practices. For example, the Land Stewardship Project (LSP) in Minnesota began to hold workshops and field days about the practice of *management intensive rotational grazing*. This involves dividing a pasture into sections or 'paddocks' with electric fences and allowing the animals to graze each area intensively for a short period of time before moving them on to another area. In conventional grazing, livestock roam freely in an open pasture, often overgrazing some areas and causing erosion.

Management intensive rotational grazing roughly mimics grazing patterns of migrating buffalo herds that preceded European settlement on the plains and prairies, but domestic livestock return to graze an area much sooner than did buffalo.

The length of time that animals graze a particular paddock usually depends upon the rate of recovery of the forage after grazing and its nutritional value, which requires farmers or ranchers to become attentive observers of their pastures and all that is growing there.

A group of farmers wanted to know how they could tell whether the switch to management intensive rotational grazing was making their farms more sustainable. In response, the Land Stewardship Project established a biological, social and financial monitoring project, conducting research on six diversified livestock and dairy farms that used management intensive rotational grazing. The project team that worked together for three years included university researchers and state agency staff in addition to the six farmers and LSP staff. To conduct biological monitoring, researchers helped the six farmers collect biological, physical and chemical soil quality data from 60 plots and make observations about pasture vegetative species and ground cover. They sampled wells and kept precipitation records. The farmers learned to survey their land for breeding birds, frogs and toads, and they helped fisheries scientists survey streams passing through four of the team farms and through one paired farm to analyse the effects of management intensive rotational grazing on stream banks and stream invertebrate and fish populations.

These farms were seen as natural habitats, not as ecological sacrifice areas. The farmers wanted to find out if the soil and the water quality in streams on their farms were improving, just as they wanted to know if their financial bottom lines were improving by cutting production costs. They were not accepting the 'inevitable', that they must get big or get out.

The farmers in the monitoring project, and many others who have been constituents of the Land Stewardship Project, practise holistic management, a decision making process based on goal setting, planning and monitoring. This process was developed by Allan Savory, who founded the Center for Holistic Resource Management in Albuquerque, New Mexico, in 1984. Land Stewardship Project staff taught many holistic management courses throughout the Upper Midwest. They developed a research project to monitor the effectiveness of management decisions made by the six farmers who had taken the course and were making the switch from conventional grazing to management intensive rotational grazing.

Holistic management contains four elements that distinguish it from conventional farm management and provide managers with strong incentives to make environmentally sound decisions. First, as part of the goal-setting process, it directs managers to develop a long-term vision for how they want the landscape to look far into the future. Second, the model teaches basic recognition of ecosystem processes that farms are dependent upon: the water cycle, the mineral cycle, plant succession and energy flow (Savory, 1998). Farmers strive to understand these processes and harmonize their farming practices with them. For example, farmers can rely on nitrogen fixation in legumes and the recycling of nutrients in manure to provide fertility for fields. Third, holistic management places a high value on biological diversity both in crop systems and in areas on the land not used for farming.

And last, practitioners consider the effect of any proposed action or choice of enterprise upon quality of life for the community as well as for themselves. They understand that their land is part of a larger whole and how they manage it will affect the landscape around them and the lives of people in the community. Holistic management has become an effective tool for those who want to be good stewards of the land and earn a living on it at the same time.

Though holistic management has been used on all kinds of farming operations, it was developed by Allan Savory in connection with rotational grazing. Farmers in the Upper Midwest often began using holistic management and management intensive rotational grazing approaches simultaneously. Cattle grazing on public lands in western states has been considered such a disaster by environmentalists that many have a negative view of grazing anywhere. However, at the landscape level in the Midwest and in parts of the Great Plains and the South management intensive rotational grazing provides visible environmental improvement in farming, especially where field crops have been converted to permanent pastures and livestock eat more grass than grain. Fewer acres of corn and soybeans also mean fewer applications of chemical pesticides, herbicides and fertilizer, which decreases the potential for contamination of surface and groundwater. When corn and soybeans are replaced by perennial grasses, there is less soil erosion (Cambardella and Elliot, 1992; Rayburn, 1993).

Dairy farmers have widely adapted management intensive rotational grazing. Between 1993 and 1997, the number of Wisconsin dairy farmers using variations of this grazing method increased by 60 per cent (ATFFI, 1996). Milk cows on most conventional dairy farms are confined in 'loafing barns' or corrals between milkings and are never allowed out to graze. On very large operations of 500–1500 or more cows, feed is brought to the cows and all of their manure is pumped out of manure pits or scraped and hauled out of the barns to be spread on fields. Conventional dairy farmers work hard to produce the corn and alfalfa to feed the dairy herd, and capital costs for equipment and barns are high. In contrast, grass-based dairy farmers usually move cattle daily but claim that their work load and costs of production are much less because the cattle walk around in the paddocks, get most of their own food, and disperse their own manure (ATFFI, 1996). With more feed produced in pastures, a farmer uses less machinery and fossil fuel (Rayburn, 1993). Some grass-based farmers 'don't have much iron', as they say, because they have sold most of the machinery they formerly needed for large fields of corn. With fewer acres planted for feed, they can share machinery with neighbours, employ custom harvesters to bring in their crops or even buy feed from other farmers. For these dairy farmers, management intensive rotational grazing is a farming practice that benefits them as much as it benefits the land and the water.

Poultry and hog farmers also use management intensive rotational grazing. Hogs can be put on pasture to graze, at least for part of their food, and spread their own manure in the grass. Hogs can spend most of their time outdoors and farrow in pastures. Farmers in the Upper Midwest often combine outdoor and indoor production systems by bringing hogs into open-ended metal hoop buildings covered with canvas for the winter. Hogs bed in deep straw or corn stalks, which composts with their manure, warming the hogs in the process and producing nearly composted, dry fertilizer for the fields when the barns are cleaned. Manure is not a toxic waste in management intensive rotational grazing or hoop house production systems, and the cost to the farmer of handling it and the public for regulating it is little or nothing. In fact, overall production costs are so much lower that farmers can make a profit as long as they have fair access to markets (Dansingburg and Gunnink, 1995) or sell cooperatively with other farmers or directly to consumers. If market prices are too low, farmers can use these hoop houses for other purposes, such as storing hay or machinery, which gives them a flexibility that producers trying to pay off the debt for a high-tech, single-use confinement facility do not have. Using management intensive rotational grazing and deep-bedded straw systems in hoop houses, farmers can take advantage of ecosystem services in providing animal feed and managing manure. These systems are efficient alternatives to the industrial production models for livestock and can compatibly exist alongside or as part of natural ecosystems.

The Benefits of Diversity

Diversified farms producing feed for their own livestock may rotate crops of alfalfa or other legumes, corn, soybeans and small grains such as barley or oats, in contrast to conventional cash grain farms that rotate only corn and soybeans or grow corn with no rotation. For example, Jaime DeRosier employs a complex rotation of hay, wheat, barley, vetch, flax, buckwheat, corn and soybeans on his large organic farm in north-western Minnesota (DeRosier, 1998). The Fred Kirschenmann farm in North Dakota rotates up to ten different grain or hay crops in three different rotations (Anonymous, 2000). In all parts of the country, farmers are also planting several different kinds of grasses and legumes in their pasture mixes, planting fields in strips of several crops, intercropping one species with another (such as field peas with small grains) and using cover crops between plantings of major crops. In California, orchards, vineyards and specialty crop farms have added cover crops and farmscape plantings to attract pollinators and other beneficial insects (CAFF, 2000).

The benefits of biodiversity in agriculture were effectively laid out in a report with that title by a task force of the Council for Agriculture Science and Technology, co-chaired by ecologist G. David Tilman and geneticist Donald N. Duvick (CAST, 1999). The report stresses the dependency of modern agriculture upon biological diversity and advocates greater attention to preserving diversity both in domesticated crops and livestock, and in the natural landscape.

The *Benefits of Biodiversity* also discusses the dependence of modern agriculture upon ecosystem services, such as pollination, generation of soils and renewal of their fertility, pest control and decomposition of wastes. It acknowledges the importance of preserving biodiversity by protecting natural areas and proposes that we substantially increase the worldwide network of biodiversity reserves and preserve large blocks of land in native ecosystems.

This report was not produced by CAST for the purpose of rerouting agriculture from the direction trends are leading. However, if followed, just one recommendation would lead us toward a landscape of farms that are natural habitats:

> Increase the capacity of rural landscapes to sustain biodiversity and ecosystem services by maintaining hedgerows/windbreaks; leaving tracts of land in native habitat; planting a diversity of crops; decreasing the amount of tillage; encouraging pastoral activities and mixed-species forestry; using diverse, native grasslands; matching livestock to the production environment; and using integrated pest management techniques.

The six farmers who participated in the Land Stewardship Project's monitoring project use many of these practices and have created more natural diversity on their land. Just by converting cropland to pasture they created new habitat for soil microbes, insects, birds, reptiles, amphibians and small mammals. Species that would have been adversely affected by chemical pesticides and fertilizers used on crops found a more favourable environment in the pastures.

Because of the emphasis on diversity and biological monitoring in holistic management, farmers in the project became advocates of diversity and astute observers of wildlife. A newsletter distributed to monitoring team members contained the following notes in a column called 'Farmer Observations':

> Mike saw first red clover blossoms on June 6. Mike saw a hummingbird on clover in his extended rest pad. He suggests that each farmer photograph their rest areas and notice the smell intensified by flowering plants. Ralph saw two baby bobolinks on July 14. He noticed the young are bunching up and may move soon. (Land Stewardship Project, 1995)

These farmers are not conventional in any sense of the word. Mike and Jennifer Rupprecht pay meticulous attention to erosion control and species diversity in their pasture, getting excited when they find native prairie species on their land. Ralph Lentz likes to show people the prairie grasses in his pastures and to talk about how he has used managed intensive grazing to improve the stability of stream banks on his land (DeVore, 1998). Dave and Florence Minar began working with a local monitoring team, after the original LSP monitoring project concluded, in the area of Sand Creek, the tributary that dumps the most sediment into the Minnesota River. Art Thicke is ecstatic when he talks about the birds he sees while moving cattle – birds that were not there when those pastures were planted to corn and soybeans (King and DeVore, 1999).

The increase of grassland birds was not just a phenomenon on Art's farm or on the other five farms in the monitoring project. Other farmers in the Upper Midwest report that they see more grassland birds such as bobolinks (*Dolichonyx* *oryzivorus*) and dickcissels (*Spiza americana*) since they replaced row crops with grass pastures. The Agriculture Ecosystems Research Project in the agronomy department at the University of Wisconsin has been comparing continuously grazed dairy pastures with rotationally grazed pastures, and preliminary results show that many more birds and more different species use rotational pastures than use continuous pastures (Paine, 1996). The increased acres of permanent grass in pasture, combined with conservation reserve land that has been in grass for several years, has created large areas of habitat for game birds also. Additional habitat is created where trees are allowed to grow again along drainages in pastures that were formerly tilled fields.

The farmers actively engaged in the Land Stewardship Project's monitoring project, and many others practising monitoring as a result of studying holistic management, are protecting or restoring diverse colours and textures in the 'warp and woof of the land use fabric'. To nurture the diversity of wildlife they have come to appreciate, and the wildlife they have begun to understand as indicators of ecosystem health, these farmers are developing and protecting more habitat niches in wood lots, along roadsides, on orchard and pasture edges, and along streams and ponds. They are leaving areas in their pastures ungrazed during the nesting season for grassland birds and removing low areas in fields from cultivation to restore wetlands.

The important point is not that these farmers have become naturalists. The natural habitat they are creating on their land is not because they set out to entice native plant and animal species to reinhabit their farms. Their management decisions and farming practices are turning their farms into a natural habitat for humans, crops and livestock, *and* wild plants and animals too. Then, as they make the connections between biological diversity, the economic health of the farm and the quality of their lives, farmers have begun consciously to make decisions to encourage even more biological diversity on their farms. Such farms should be the model for agriculture in the 21st century. To make that happen, a large group of constituents are needed who understand the possibilities for farms to be natural habitats and to transform rural landscapes.

Building a Constituency

Aldo Leopold wrote that no government conservation programmes with their subsidies for farmers could cause landowners to take good care of the land unless they felt an ethical responsibility for it. The ultimate responsibility for conservation was the farmer's (Leopold, 1991). From the latest agricultural census, we can see that less than 2 per cent of the US population are farmers (USDA, 1997), and not all of them are the family farmers Leopold had in mind but include large-scale farmers managing thousands of acres, often on behalf of investors or on contract with corporations. There are not enough private landowners on farms to rescue the agricultural landscape from ruin, even if those that exist possess a strong land ethic. We would be foolish to depend upon giant producers and processors such as Tyson, IBP and Smithfield corporations to exercise a land ethic. Whose responsibility is it then? It is a public responsibility. Good farming produces public goods, and the public must support good farming. Instead of accepting industrial agriculture as a necessary evil and counting on regulations to soften its negative environmental and social consequences, the public (particularly conservationists and environmentalists) should use their dollars and their votes and their influence to bring about agroecological restoration.

If asked whether it is all right to consider agricultural land as an ecological sacrifice area, most conservationists would loudly say no. But without thinking about it, many have acquiesced to the inevitability of farms becoming corporate factories when they have been involved in state or national processes to establish regulations for feedlots. Activist organizations have worked for strong regulations of nonpoint source water pollution and confined animal feeding operations, and their chief opponents have often been farmers, or farm organizations, which has caused them to develop antagonism for farmers. Many have not had the opportunity to know farmers whose diversified livestock systems operate without need of regulations. If conservationists could get to know farmers who are stewards of the soil, water and the wild and learn about their management philosophy and the farming practices they use, perhaps they would see possibilities for making basic changes in US agriculture that would restore rural landscapes to greater biological diversity and environmental health.

Dave Palmquist, the interpretative naturalist at south-east Minnesota's Whitewater State Park, the most popular park in Minnesota with about one-third of a million visitors a year, knows a stewardship farm family. He has taken groups of campers 10 miles away from the park to visit the 275-acre farm owned and operated by Mike and Jennifer Rupprecht, one of the six farms in LSP's monitoring project. His reason: 'There's an increasing understanding you can't save the world within state parks. The sixty-five little pieces of Minnesota (state parks) aren't going to do it. If you have to go outside your park to tell an important story that relates to the park area, do that.' Palmquist believes that visitors are impressed. 'It's clear to the visitors that these farmers embrace diversity and see themselves as being part of the bigger environment. The more diversity, the more bobolinks, bluebirds, etcetera, they have on their land, the better they feel. If they can make a living there, maintain a family farm, and be gentler on the environment, that's very exciting for them' (DeVore, 1996).

This kind of agroecological restoration is occurring on many farms today, illustrating that farms can be managed to give rural landscapes a mixture of agricultural and natural ecosystems that preserve much of local biodiversity and provide ecosystem services essential to agriculture. We need the heirs to Aldo Leopold's thought and inspiration and those who respect the work of modern ecologists such as David Tilman and naturalists like Dave Palmquist to help society see this vision of the farm as natural habitat and work to turn it into reality.

Conclusion

This vision does not promise that a landscape of such farms will reproduce the ecosystem that existed before white Europeans conquered the land, but neither will it be covered with factories. When farms are factories, they produce commodities and profit for agribusiness and charge external costs to the land and rural communities. When farms are natural habitats for humans, domesticated crops and livestock, and also for wild plants and animals, they produce food and multiple other benefits for society. And such farms can be the sources for further ecological restoration in the landscape.

No doubt interspersing a variety of uses on farms will mean different problems to overcome than those we now face, both ecologically and economically, because we still have a lot to learn about farming with the wild. Creating farms as natural habitats will require more sophisticated strategies for disease and pest suppression in crops and livestock. It will also require greater emphasis on diversification and resilience and less emphasis on simplification and short-term fixes. These are problems in farming that require ecological solutions.

Farming-system problems can be solved. The perhaps intractable problem is how to influence social evolution so that a land ethic, and not pure utilitarianism, guides land use decisions. We need all people to look at farming with new eyes, to see the potential of the farm as natural habitat, and to refuse to accept the inevitability of farms becoming rural factories to serve the global economy. We must teach that 'the land is one organism'.

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Part III

Communities and Social Capital

11

Feminism and Environmental Ethics: A Materialist Perspective[1]

Mary Mellor

Feminism and Environmental Ethics

An important starting point for the development of an environmental ethics must perforce lie in the experience and situation of women (Gruen, 1994). This is, however, not the only starting point. Human society has many other divisions besides gender, but this paper is specifically concerned with a feminist perspective on ethics. The core of my argument, one that has been made many times by feminists, is that women's lives in a gendered society are grounded in the materiality of existence, in the cycles of birth and death and bodily needs (Ruddick, 1990). However, in stressing the importance of a feminist analysis to environmental ethics, I would not want women to be seen as the solution to environmental damage and injustice and thereby deflect attention from the problem of male domination and exploitation of women and the natural world (Mellor, 1992a, p81). I wish to argue that a solution to the questions of environmental justice and environmental ethics needs to start from an understanding of the social relations underpinning current patterns of unsustainability together with an understanding of the material relations between humanity and nature. This involves a three-fold relationship between human and human and nature and a double dialectic, between human and human (patriarchy, capitalism, racism), and between humanity and nature.

This complex relationship requires a breadth and depth of analysis that can integrate an analysis of social relations with ecological relations. In such a context all parts contain active elements. The relationship between humanity and nature is heavily circumscribed by relations between human and human. In turn, the dynamic between humanity and its natural context limits or constrains choices or brings unwelcome consequences. For this reason I would argue that a 'deep' analysis is needed, which I have called deep materialism. This analysis has three starting

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points, the ecofeminist insight that there is a relationship between the subordination of women and the exploitation of nature, the deep ecologists' argument for a nonanthropocentric ontology and cosmology and the Marxist analysis of the dialectical relations of human material life.

The concept of deep materialism combines the adjective adopted by deep ecology and the analytical framework associated with Marx. I would argue that the insights of both are important and there is no necessary conflict between a radical approach to human–human relations and a 'deeper' approach to human–nature relations, although there are tensions between them in practice. The source of these tensions is the priority in different perspectives given to human–nature relations as against human–human relations. A radical approach to ecology such as that of Bookchin (1989) would see a fundamental reorganization of human–human relations as essential to resolving human–nature relations. Deep ecology, on the other hand, would see human–nature relations as the critical element. I would argue that the one is inseparable from the other, human–nature relations require reformulation of human–human relations and vice versa. Ecofeminists would agree with deep ecologists that humanity needs to completely rethink its orientation to the natural world, but like historical materialists would point to the socioeconomic context of such a relation. I would argue that Marx had at the heart of his work the double dialectical framework that I am advocating, but that his later analysis and, more importantly, later interpreters, took a humanist turn that lost the dialectic between humanity and nature. Marx's inability to develop his ideas in a more ecological direction was largely due to his acceptance of the sexual division of labour (Mellor, 1992b). Ecofeminists have also criticized deep ecology's tendency to concentrate on the relationship between humanity and nature to the exclusion of the dynamics of intra-human, and particularly gender, relations (Salleh, 1992). This leads to a tendency to adopt a depoliticized and even anti-human stance which places the blame for the ecological crisis on an undifferentiated 'humanity'. Ignoring social difference and inequality puts equal responsibility for ecological damage on the North and the South, rich and poor, black and white, men and women. This is not to imply that deep ecologists do not recognize the existence of what Naess called the relationship between 'man and man' (sic) but that this tends to remain theoretically unexplored. For ecofeminists the question of sex/gender difference/inequality is vitally important given the gendered nature of the relationship between humanity and nature.

Discussions of humanity, man, woman and nature are conceptually problematic. Humanity is divided in countless ways, as are men and women. I would not go along the postmodernist road that claims that there is no extra-discursive category of 'woman' (Riley, 1988), but it is easy to slip into universalizing and essentializing frameworks of thought when the words 'man' and 'woman' are used. Equally nature is a deeply problematic concept (Soper, 1995). I hope in the course of this paper to make clear the way in which I am using these words. However, to indicate the problematic and divided nature of humanity I will write this word in a broken form, hu(man)ity, in the rest of this chapter.

Ecofeminism and the Woman/Nature Relation

Ecofeminism has been identified as part of a 'deeper' or more radical approach to the ecological crisis (Merchant, 1992; Eckersley, 1992; Dobson, 1995). What is contentious in ecofeminism is the way in which the relationship between women and nature has been represented. Elsewhere I have made the distinction between affinity and socialist/social contructionist ecofeminism (Mellor, 1992a, 1996), that is between those who see women as having a bodily or cultural affinity with the natural world through their woman-ness as mothers, life-givers, nurturers, carers, and those who identify similar activities associated with women but see these as imposed upon women by male-dominated societies.

Affinity ecofeminists such as Andree Collard (1988) adopt a radical difference perspective seeing men/patriarchy as the source of eco-destruction and women as the contemporary representatives of an 'ancient gynocentric way of life' (p14) that exhibited 'nurturance-based values which women experienced and projected not only on their goddesses but on to every creature among them' (p8). The distinction between men and patriarchy implies that men are not necessarily bad, although Collard appears to wish to assert that all women are good. The source of women's affinity with nature is their common identity as mothers 'whether or not she personally experiences biological mothering' (p102). Men will be redeemed if they abandon patriarchy and embrace the values associated with women. What will motivate men to do so is less clear and as with much feminist writing that describes the patriarchal destruction of original matriarchal/egalitarian society the origin and nature of patriarchy is problematic. Collard suggests that male envy of women's ability to create life may be a psychological underpinning of patriarchy.

Affinity ecofeminism does not necessarily see masculine–feminine dualism as destructive. Instead they can be seen as complementary (Henderson, 1983). Cosmologically the masculine and the feminine are seen as the two complementary sides of a common hu(man)ity that have become disaggregated in ways that are socially and ecologically dangerous. Destructive behaviour occurs because masculine values are currently too dominant, more emphasis on feminine values are needed to restore the balance. I have described this as an ecofeminine rather than an ecofeminist perspective (Mellor, 1992c).

In contrast to asserting the affinity of women and nature, ecofeminists who come from an anarchist or socialist background tend to see sex/gender inequality as resting on other social inequalities. Women's association with nature is not explained by women's 'natural' affinity, but is socially constructed. Ynestra King (1990), from an anarchist perspective, sees sex/gender inequality as part of the wider question of hierarchy in society. She sees women as being 'historically positioned' at the 'biological dividing line where the organic emerges into the social' (pp116–117). Carolyn Merchant (1990), from a socialist feminist perspective, sees environmental problems as 'rooted in the rise of capitalist patriarchy and the ideology that the Earth and nature can be exploited for human progress' (p103). However, neither King nor Merchant seeks to radically dissociate themselves from cultural ecofeminism and the importance of valuing women and women's work. Merchant sees all the many strands of ecofeminism as being concerned with 'reproduction construed in its broadest sense to include the continued biological and social reproduction of human life and the continuance of life on earth' (p209).

Although ecofeminists often make generalized statements that seem to refer to all men and all women, their specific focus is the pattern of dominance that arose in European society associated with the historical development of science, technology, industrialism and capitalism. This is not to ignore the fact that earlier societies have been ecologically destructive (Ponting, 1991) or that ecologically benign societies can be patriarchal. It could be argued that male domination and women's oppression have been more ubiquitous in history than ecological destruction. The interesting question for ecofeminists is the way in which the two have come together in the present era. Ecofeminists see the origins of the present ecological crisis as lying in the specific material and cultural developments of the North/West as reflected in its socioeconomic structures, science and technology, philosophy and religion. For many ecofeminists, particularly those with a theological or a philosophical background, this destructiveness results from the forms of knowledge and belief that justify and sustain Western patriarchy. In particular, the Christian and rationalist rejection of the body and the prioritization of mind or soul (Ruether, 1975; Plumwood, 1993). Women are essentialized, naturalized and condemned by their association with the body. This association I would argue is the basis of the materialist analysis that can be derived from ecofeminism.

Materialist Ecofeminism

Materialist ecofeminism is based on the assertion that sex/gender inequality is not a by-product of other inequalities, but represents a material relation of inequality between dominant men and subordinate women. In terms of the double dialectic, the human–human relation is gendered in such a way that it interacts with the human–nature dialectic. Women are materially placed between 'Man' and 'Nature'. In a very real sense gender mediates human–nature relations, and *mediation* is a concept central to materialist ecofeminism. An environmental ethic between hu(man)ity and nature cannot be developed if this gendered relationship is not acknowledged. The second important element is the position of women as embodying nature both materially and symbolically in gendered societies. Unlike dominant men who claim to be above nature (transcendent), women are seen as steeped in the natural world of the body (immanent). The concept of *immanence* is therefore another central concept for materialist ecofeminism.

Affinity and social constructionist ecofeminism both see masculine/patriarchal values as inherently damaging and destructive, but even affinity ecofeminists do not see *men* and *women* as in fundamental conflict. Despite the initial impression given by their rhetorical language and condemnation of man/male and praise for women/the female, most do not see men as a lost cause. The problem arises with patriarchal structures which 'emerge' as cultural forms. When these structures are confronted and defeated, men and women can adopt a suitably earth-centred approach. For social constructionist ecofeminists, the most important structures that have created and/or sustained the hierarchical dualism of male–female are Western cultural and/or socioeconomic structures. This hierarchical dualism is symbolized by the emergence of a dominant public world based on a conception of rationality that seems to exclude women as participants (Lloyd, 1993) and the natural world as an entity worthy of moral concern (Plumwood, 1993; Warren, 1994). Although Plumwood and Warren would tend to see the cultural/philosophical framework of western society as fundamental, from a materialist ecofeminist perspective I would argue for an approach starting from sex/gender dualism as a relation of (re)production. This reflects a material necessity rather than a cultural/philosophical construction. In all human societies the need exists to construct the social within the constraints of the agency of the natural. This is exacerbated by the dualist and sexist structures of western society.

The dilemma of human embodiment exists as a fundamental feature of the human condition but it becomes most destructive in the divided societies of capitalist patriarchy where domination and transcendence of the natural world is central. With Ariel Salleh (1994) and Ynestra King (1990), I would argue that the sex/gender division of labour around human embodiment is the crucial factor. Women are materially associated with, and largely responsible for, human embodiment whether as paid or unpaid work. Although feminists have traditionally opposed women's association with the 'natural' work of mothering, nurturing, and caring, ecofeminists have followed cultural feminists in revaluing women's work. Materialist ecofeminism analyses the material relations of sex/gender in terms of the demands of human physical embodiment and ecological embeddedness. Unlike earlier traditions in feminism which sought to join male-dominated society in its seeming transcendence of natural conditions and the constraints of domestic life, ecofeminists have embraced immanence rather than transcendence. Immanence has been described by an ecofeminist exponent of the pagan tradition of witchcraft as the embracement of hu(man)ity within the alive-ness of the natural world (Starhawk, 1990). I would agree but would prefer to express these ideas in physical rather than magical terms. Alive nature may be, but it is not supernatural.

The dilemma for ecofeminism is that its two elements are in contradiction to each other. Although feminism has historically sought to explain and overcome women's association with the natural, ecology is attempting to re-embed hu(man)ity in its natural framework. Ecofeminism generally is incompatible with 'equal opportunities', liberal/equality/humanist feminism, and there are obvious dangers for the equalities that (some) women have achieved in going back to an association of women with nature whether it is on an affinity, social constructionist or materialist basis. From a deep materialist analysis it is not possible to see sex/gender relations as entirely socially constructed. It is no accident that women were associated with nature, it was not a mistake or some historical legacy as Ulrich Beck

(1992) has argued. As I will argue here, and have argued elsewhere, the association of women with nature represents hu(man)ity's need to confront its own materiality, its existence in ecological and biological time (Mellor, 1992a). The relationship is not a contingent one, an accident of historical association, it is a structural relation (Mellor, 1996).

Hu(man)ity as a natural species is embodied in its physical being and embedded in its natural context. Ecological time is the time framework of ecological renewal and of ecological change and evolution. Hu(man)ity can interfere with this to a large extent, but rarely without consequences in the long term, for even the most privileged, while in the short term it is the least privileged and other species who suffer most. Biological time is the life cycle and rest/renewal timescale of the human being. The centrality of women's socioeconomic position in this relationship is her responsibility for biological time.

The basic argument of materialist ecofeminism is that Western society has created itself against nature using the sex/gender division of labour as (one) of its vehicles. That is, power is defined by the ability of certain individuals and groups to (temporarily) free themselves from embodiedness and embeddedness, from ecological time and biological time. Ecological time as representing the pace of ecological sustainability for non-human nature. Biological time representing the life cycle and pace of bodily replenishment for human beings. It appears that throughout history women have carried the burden of biological time, and as Shiva (1989) has argued, in subsistence economies operated within ecological time. As Sanday's (1981) survey of anthropological data has shown, this left social space and time largely in the hands of men. Although men may have exploited their 'free' time in traditional society to make war, trade and politics, the position is much more dangerous in modern industrialized and militarized societies. The hallmark of modern capitalist patriarchy is its 'autonomy' in biological and ecological terms. The sex/gender and ecological consequences of economic activities are cast aside as 'externalities' (Mellor, 1997a). Western social and economic structures are based upon an idealized image of individuality. Western 'economic man' is young, fit, ambitious, mobile and unencumbered by obligations. This is not the world that most women know. Their world is circumscribed by obligated labour performed on the basis of duty, love, violence or fear of loss of economic support. To take their place in the Western public world, women have to present themselves as autonomous individuals, 'honorary men', avoiding domestic obligations, undertaking them in their 'free' time, or paying someone else to carry out that work.

Mediation in Human–Nature Relations

A materialist ecofeminist identification of women and nature is not based on an essential affinity, but reflects women's role as mediators of human–nature relations. It is not women's identity with 'nature', either as biology or ecology, that should form the basis of ecofeminism, but a material analysis of the way in which male domination is created and sustained. As Mies et al (1988) have argued, women are one of the 'colonies' of capitalist patriarchy. They are 'paying the price' (Dalla Costa and Dalla Costa, 1995). Women's identification with the 'natural' is not evidence of some timeless unchanging essence, but of the material exploitation of women's work, often without reward (Waring, 1989). It is not even always just the work that women do, but their availability. Someone has got to live in biological time, to be available for the crisis, the unexpected as well as the routine. Although materialist ecofeminism points to the particular dynamic represented in the sex/gender dualism, this is only one pattern of mediation. I see materialist ecofeminism as contributing to a wider debate about the material relations into which humans enter when confronting their embodiment and embeddedness. Marx's historical materialism addressed the social relations of class in this context. Later analyses have seen racism and imperialism/colonialism as equally, if not more, important. These dimensions are not in a hierarchy of oppressions, but rather a matrix that cut across each other (Collins, 1990).

Mediation involves both exploitation and exclusion. Mediation is making time, space or resources for someone else. Even so, the world is not clearly divided into mediators and the mediated. Many people stand in complex networks of mediation. Mediation is not only carried out by women, in fact, many women are themselves the beneficiaries of mediation. White Western women may mediate biological time for their family, but exploit the labour of others, the resources of the South, and the sustainability of the Earth. Many people live in complex networks of mediation on the basis of 'race', class, gender or ethnicity. The most destructive, however, are the industrialized societies of capitalist patriarchy that rest on a huge network of mediation through exploitation and exclusion: of women, of workers exploited or excluded on the basis of class, 'race' or gender, through the expropriation of colonized lands and the exclusion of colonized peoples. Environmental justice is about the social and ecological consequences of that 'freedom' exercised by the minority at the expense of the many (Hofrichter, 1993). The insight of ecofeminism that is common to both affinity and social constructionist ecofeminism is that the needs of human embodiment are shared by all hu(man)ity but are disproportionately borne in the bodies and lives of women.

Ecofeminism, in bringing together the domination of women with the domination of nature, brought into sharp focus the central dilemma of feminism: how could women's association with nature be asserted without falling into an essentialist and naturalist trap? The answer lies in not seeing women's oppression as representing their 'natural' affiliation with the natural world, but the connectedness of all hu(man)ity with nature. Women do have particular bodies which do particular things, but what matters is how society takes account of sexual differences and the whole question of the materiality of human existence. That is why I have linked the concepts sex/gender, to represent the interconnections of the biological and the social. Women are not closer to nature because of some elemental physiological or spiritual affinity, but because of the social circumstances in which they find themselves, that is, their material conditions in relation to the materiality of human existence.

In order to explore materialist ecofeminism as a perspective, it is necessary to bring together the green perspective on human–nature relations and a materialist feminist perspective on sex/gender relations. In this sense materialist ecofeminism is more sympathetic to deep ecology than other radical ecological perspectives such as social ecology or ecosocialism (Pepper, 1993). Getting the relations between humans right will not resolve the ecological imbalance because the source of much of the conflict between humans is the unacknowledged problem of immanence. Although both Bookchin and Marx explored the dialectical nature of the relationship between hu(man)ity and the natural world, other aspects of their work have prioritized hu(man)ity at the expense of non-human nature. Bookchin (1995) has called for the 're-enchanting' of hu(man)ity as the focus of social and natural agency, and the later Marx and Marxism have focused upon the social construction of nature. More recently, however, Marx's green credentials have been reclaimed or asserted (Benton, 1996). From the following it is clear that Marx saw hu(man)ity as both embodied and embedded within its natural 'body':

> Species-life, both for man and for animals, consists physically in the fact that man, like animals lives from inorganic nature… Man *lives* from nature, i.e. nature is his *body*, and he must maintain a continuing dialogue with it if he is not to die … for man is part of nature… Communism as fully developed naturalism, equals humanism, and as fully developed humanism equals naturalism: it is the *genuine* resolution of the conflict between man and nature. (Marx 1844/1975, pp327, 348, italics in the original)

As I have argued more fully elsewhere (Mellor, 1992b, 1997b), Marx's theory does contain the basis for a deep materialist analysis, but for ecofeminism the more immediate and contemporary statement of hu(man)ity's relationship with the natural world has been developed by deep ecology.

Deep Materialism and Deep Ecology

Deep ecology contributes to deep materialism through its aim of re-evaluating the relationship between hu(man)ity and non-human nature. The problem is how is this to be achieved? What would motivate hu(man)ity (or those parts of it with the power to make fundamental decisions) to change its stance towards non-human nature? Obviously a changed ethic would achieve this aim, but I see this as the goal rather than the means. The weakness of ethical approaches is the question of political agency. Ethical approaches are by their nature idealist (and idealistic) and require a metatheory of the motor of social change, which Marx provides in his materialist challenge to idealism. Do ideas change social structures and relations or do changing structures produce new ideas? Obviously it is a bit of both, and the economic determinism that dogged Marxist theory underestimated the role of ideas in changing human consciousness/awareness. However, I would argue that a deep materialist analysis provides a firmer basis upon which to establish grounds for political agency than an idealist philosophical/ethical stance.

Deep materialism shares with deep ecology a view of nature as embracing hu(man)ity. As Eckersley expresses it (following Naess) the world is 'an intrinsically, dynamic, interconnected web of relations in which there are no absolutely discrete entities and no absolute dividing lines between the living and the nonliving, the animate and the inanimate, or the human and the nonhuman' (1992, p49).

The insight of deep, green thinkers has been the conception of the natural world as having its *own* ontological status. Non-human nature is not a social construction or a dead nature that transcendent humans can manipulate at will and without consequences. It is an alive nature that enfolds human beings. The radical ecological (and ecofeminist) criticism of Western culture is that its dualistic social structures and forms of knowledge ignore the fact that hu(man)ity is part of the natural world (Plumwood, 1993). Hu(man)ity is always immanent. Transcendence is socially constructed against 'nature'. The natural world is not dead or dumb or a product of the human mind, it is '*fundamentally material and subjective*' (Lahar, 1991, p37, italics in the original). It is real, dynamic, and always beyond human knowing in that imbedded hu(man)ity has no Archimedes point from which to assess the complex interrelations of all the forces of the natural world. Ecologically hu(man)ity exists in a condition of radical uncertainty.

The concept used by deep ecologists to express a nature-centred approach is ecocentrism as opposed to human-centredness or anthropocentrism. Despite the claims of deep ecologists to a holistic framework, nature-centredness (ecocentricity) in rejecting human-centredness (anthropocentrism) tends to see human society as out of step with 'nature'. This implies a dualist distinction between 'humanity' and 'nature', where nature is 'right' and hu(man)ity is 'wrong'. Ecocentrism is often expressed in a way that sees hu(man)ity as outside of 'nature', particularly in the emphasis on wilderness. 'Untouched' nature is more 'natural' than when peopled by human beings. From a deep materialist perspective I would argue that human beings are inside, not outside of the processes of life. They have evolved out of the physical materials of this planet and their intelligence and destructiveness is part of that natural process. Nature does not have moral position on hu(man)ity. Hu(man)ity just is, as it is. It is for hu(man)ity itself to judge the ecological impact of its own existence. In this sense we cannot escape human-centredness. Nature is how we see it now. However, where the deep ecologists are right is to accuse modern humanism of arrogance in its attitude to the natural world. Human beings, no matter how powerful, cannot determine the ultimate conditions of their own existence. Nature will go on with or without hu(man)ity. The concept I would use to express the immanence of the human condition and the need to embrace a more nature-aware ontology is ecological holism. Ecological holism sees hu(man)ity as part of a dynamic interactive ecological process where the whole is always more than the sum of its parts (Mellor, 1997b, p185).

Ecological Holism and the Limits of Deep Ecology

In denying the moral worth of human agency, deep ecologists have a problem in making the jump from an ontological assertion of human interconnectedness with the natural world to the philosophical grounds for political action that goes beyond moral extensionism (Devall and Sessions, 1985; Devall, 1990; Fox, 1990; Eckersley, 1992). Where a deep materialist analysis would look at the material relations of hu(man)ity's (mal) connectedness with its encompassing environment, deep ecology tends to adopt an idealist framework as in Devall's and Sessions's (1985) concept of 'ecological consciousness':

> Deep ecology goes beyond the so-called factual level to the level of self and earth wisdom … to articulate a comprehensive religious and philosophical worldview … the basic intuitions and experiencing of ourselves and Nature which comprise ecological consciousness (p65).

A similar idea is expressed in Fox's (1989) transpersonal ecology with its notion of a transpersonal Self that represents the cosmos:

> deep ecologists emphasise identification within a cosmological context – that is, within the context of an awareness that all entities in the universe are part of a single, unfolding process (p11).

Following Naess, Fox (1990) argues that humans will understand nature's cosmology through an expanded sense of the Self. This is not the 'egoic, biographical sense of self', nor one that humans attain individually or collectively through ethical or political development, rather it is a Self that comes in from the outside:

> a transpersonal approach to ecology is concerned precisely with *opening* to ecological awareness: with realising one's ecological, wider, or big Self (p199, italics in the original).

Transpersonal ecology's cosmology requires a new way of looking at the world. For Fox this is the image of the cosmos as an unfolding 'tree of life'. We are all leaves on that tree. Adopting this new worldview through Self-realization and attaining ecological awareness, links hu(man)ity with the spontaneous unfolding of the cosmos. This is both teleological and idealist, reaching for the 'cosmic mind' of nature, a timeless essence revealing itself. The Naess/Fox/Devall/Eckersley approach to deep ecology claims that if true ecological consciousness were achieved, then moral injunctions would not be necessary:

> The cultivation of this expansive sense of self means that compassion and empathy naturally flow as part of an individual's way of being in the world rather than as a duty or obligation that must be performed regardless of one's personal inclination (Fox quoted in Eckersley 1992, p62).

The idealism of this perspective means that human–nature relations are not realized through the materiality of human connectedness to the natural world per se but by an individual appreciation of the *Idea* of connectedness. If such a cosmology is 'naturally' available, why does hu(man)ity not exhibit ecological awareness already? Ecofeminists argue that deep ecology fails because its concept of the self/Self is androcentric and therefore does not recognize the importance of the gendered nature of human–nature relations (Salleh, 1992; Plumwood, 1994; Mellor, 1997b).

Ecological Holism and Immanent Realism

In contrast to the idealist approach taken by most deep ecologists, I would see human envelopment in 'nature' as a material relation, an immanent materialism, that is the historical unfolding of the material reality of human embodiment and embeddedness within its ecological and biological context. However, I would not see this as having any particular direction in the sense of a determined outcome (which is implicit in both deep ecology and Marxism although in very different terms), although plainly some constructions of human–nature relations are more sustainable for hu(man)ity and current ecological conditions than others. Establishing a sustainable relationship for itself within its natural framework requires hu(man)ity to make political and moral choices. Human-centredness and the need for human appraisal of the social and ecological situation cannot be avoided. Nature has agency and history, but no mind or goal. Throughout my work I have argued for a politics of social and environmental justice based on feminist, green socialism (Mellor, 1992a, 1992b, 1993, 1997b). This inevitably means a struggle around ideas, but those ideas are grounded in a material analysis of the social and ecological context.

Materialist ecofeminism has strong links with critical realism (Plumwood, 1993; Hayward, 1994; Dickens, 1996) and feminist epistemology (Haraway, 1991; Harding, 1993; Rose, 1994). Critical realism challenges Western culture's attachment to positivist, scientific knowledge in terms of the social relations that are contained within them. As Hayward argues, 'sound critical social theory is as important as natural knowledge and ecological goodwill' (1994, p86). To this I would add the need for an immanent critical realism that would check the tendency towards assumptions of human supremacy in some critical social theorists. Bookchin (1995), for example, in his argument for the re-enchantment of hu(man)ity tips the balance of his dialectical naturalism towards human rationality and creativity. His approach is also teleological in that he sees hu(man)ity as at the apex of an evolutionary process. Hu(man)ity's job now is to rationally redirect the natural world. I would agree, but without the assumption of human supremacy. From the perspective of ecological holism and radical uncertainty hu(man)ity is an accidental outcome of nature, a momentary flicker in planetary history. If it is to remain for more than a brief moment, rational direction of its own history in relation to its natural context is essential for hu(man)ity. For this reason critical realism, based on a purely social critical theory, will not provide a solution. A deep materialist analysis would want to give more agency to the ecological whole and emphasize the radical uncertainty of human existence.

Hu(man)ity's immanence will always mean that any knowledge about the natural world is always partial. Even if a knowledge of all the components of the natural world was assembled this would never reveal the dynamics of the whole. The interconnectedness of all existence means that the ultimate consequences of any particular act can never be known. Immanent realism demands first of all a profound awareness of the ecological whole. There are many ways in which immanence could be 'realized'. It may be possible to achieve this through a scientific understanding, but it could also be achieved through the 'spiritual' awareness that many people feel when confronted by natural forces. Equally, the physiological experience of embodiment, embracing the realities of life, love and death, could be another channel of awareness. In this sense there is a material basis for the claim that an ethic based on women's lives and experience is likely to be more relevant to ecological sustainability. Spiritual ecofeminists are also perfectly logical in saying that it is possible to think through the body or experience holism as a spiritual force. It may be that ecological holism can only be experienced as a 'revelation', which could be described as wisdom. However, I would argue against seeing spirit as a metaphysical or supernatural concept, but rather as a particular property of human consciousness (Mellor, 1997b, p187).

Awareness of the radical uncertainty of human immanence should be the starting point of all other knowledge. This requires recognition of the *essentially* dialectical nature of the relation between hu(man)ity and the dynamic ecological whole. It would also recognize the independent agency of the interconnected whole. This does not deny human agency, but human agency would always need to show ecological reflexivity and humility. Such an approach does not take moral or political agency or even scientific knowledge from hu(man)ity, in fact it makes them all more vital. The loss of the positivist scientific assumptions that the machinery of nature will be revealed cannot be replaced by an equivalent assumption of a revelation of the holistic 'meaning' of nature. If the dynamic whole is unknowable by traditional scientific methods, why should it be any more 'knowable' through an ecological metaphysics?

Ecofeminism and the Politics of Deep Materialism

As I have implied earlier, I see no reason why hu(man)ity should be in harmony with a holistic nature. What is special about hu(man)ity is that it can grasp the tenacious nature of its existence. However, a transcendent dominant elite mediated by sex/gender and other relations of exploitation are unlikely to be motivated to 'see' the vulnerability of human immanence. Even when this vulnerability is grasped, this does not mean that hu(man)ity can reclaim an original harmony that has been lost or a teleological harmony to come as many green thinkers imply. If anything, hu(man)ity is *essentially* in conflict with non-human nature in using human consciousness and reflexivity to create a special and privileged niche. In doing this hu(man)ity is neither natural or unnatural. Therefore, deep ecologists cannot say 'nature' would be better off without hu(man)ity. However, hu(man)ity cannot exist without 'nature' and as there is no 'natural' way for hu(man)ity to relate to it, human existence in nature becomes a political and moral question. How can we live? How ought we to live? This is human-centred in orientation and motivation but the political conclusions would need at least to recognize the ecological framework of human activity. This would not satisfy deep ecologists but it would go much further towards balancing human–nature relations than most current political theory and practice. If, as I have argued, there is no natural balance in 'nature' and as hu(man)ity cannot transcend its ecological connectedness, a sustainable connectedness for hu(man)ity would need to be created through human reason and political action. In short, a politics of human–nature relations (Mellor, 1997b, p188).

Such a politics would start from an analysis of the structures that have created the present pattern of malconnectedness between the dominant structures within hu(man)ity and non-human nature. For ecofeminism, the subordination of women, particularly as represented in Western dualist social structures and patterns of thought, is central to understanding the destructiveness of current human–nature relations. In bringing together ecology and feminism, ecofeminists see women and nature as subject to the destructive socioeconomic and technological systems of modern male-dominated society. Sex/gender is put at the heart of this analysis, but this is not to exclude other cross-cutting dimensions of oppression and exploitation. To start with one oppression is not to claim that it has precedence, but to see if elements of the analysis may be useful in looking at other oppressions.

The focus of materialist ecofeminism on sex/gender inequality in the construction of human–nature relations does not collapse the social into the biological/ecological, but it does not seek to radically separate them. Materialist ecofeminism sees all hu(man)ity as embodied and those bodies are sexed. Gender does not map directly on to sex and sex itself is heavily socially circumscribed. 'Man' and 'woman' are the product of the interaction of biological and social factors. There is no essential or universal type of man or woman, but 'men' and 'women' do exist with enough commonality to make such concepts practically and theoretically useful. For materialist ecofeminism, there are aspects of women's bodies and social experience that can usefully be explored to help understand the current imbalance in human–nature relations. This imbalance has occurred within the context of a global system that is male-dominated, specifically by men from economically dominant societies with a history of war, militarism and imperialism, nationalism, racism and colonialism. The problem for such a society is how political change can occur. Certainly, there is the case for a struggle around ideas and ethical frameworks, but this has to be combined with struggle around material relations. The dualism at the heart of Western patriarchy is both material and cultural/ideological. Capitalist patriarchy justifies its transcendence through the promise of (eventually) extending transcendence to all, including those who are now locked into the hierarchical mechanisms of mediation. Universal transcendence is a promise that in ecological terms capitalist patriarchy cannot achieve. If it attempts to extend the patterns of consumption already achieved in the most successful economies, capitalist patriarchy will at some point run up against ecological limits. If capitalist patriarchy does not continue to extend its economic reach, it will fall victim to the classic Marxian problem of failure to realize profits and the inability to ideologically control those it exploits, excludes and oppresses.

The limitation of Marxist theory is that it only takes account of one form of mediation, class exploitation. Materialist ecofeminism would extend historical materialist analysis to all mechanisms of mediation. Political agency would rest with any peoples or groups who are exploited, marginalized or excluded by transcendent structures of social and ecological exploitation: people who have lost their land, economic migrants, bonded labourers, underpaid or unemployed workers, those suffering from biological and ecological hazards, floods, drought, pollution, industrial injury, ill health, people subordinated, oppressed and exploited on the basis of ethnicity, 'race' or gender. I would not want to make the case that all or any of these groups hold the answer to ecological sustainability or that they are likely to be more ecologically benign given the chance. The point is that their chances are limited socially or ecologically to a greater or lesser extent and this unites all these struggles. This is why building coalitions and coordinated political action are essential. Collective power will come from networks of people and groups all over the world making these connections, building coalitions of struggle not just around ideas but material conditions. The rather comfortable green concerns of the middle class in Europe, the US or Australia are not so indulgent if they are connected and identify with the campaigns of indigenous peoples for their land and cultural heritage, the position of the landless and the workless, ecologically and economically threatened communities, as well as campaigns around species and habitat (Mellor, 1997b, p192).

An ethics for social and environmental justice will not be 'given' to hu(man)ity by nature, it will always be a construct of human reason, informed by a critical awareness of the dynamics of socioeconomic power. However, developing such an ethic must take place against the background of a nonanthropocentric ontology. Hu(man)ity is essentially limited and framed by the unknowable and uncertain agency of the natural world. Immanent and alive nature embraces hu(man)ity. Failure to comprehend the materiality and material consequences of the human condition occurs where dominant social groups use the labour and resources of others (human and non-human) to mediate between themselves and their biological/ecological conditions. This is the three-way relationship of the double-dialectic of human–human–nature relations. The constraints of human existence as natural beings are mediated through unequal human–human relations. The development of an environmental ethics and the claim for environmental justice must be based on an analysis of these relations.

Materialist ecofeminism argues that the gendered nature of the relation between hu(man)ity and nature means that dominant males (and the females who associate with them) can live in conditions of unsustainable transcendence. Appeal to an environmental ethic may undermine these dominant groups, but it is important to recognize that all human beings are to a greater or lesser degree caught up in the web of mediation. Within that web three points of agency can be identified that may enable change to occur. The most obvious is the planet's own response to human action. The ecological effects of human action such as ozone depletion and global warming, unlike desertification and localized pollution, affect the dominant as well as the subordinate. Another locus of struggle are the campaigns by those who are subject to social and environmental injustice. Desertification, commercialization of land, destruction of local habitat, all produce economic and social dislocation and political responses such as land claims which the so-called 'developed' world is finding increasingly difficult to ignore. Finally, I would not want to underestimate the power of ideas and the growth of personal awareness. We are all embodied, and even the richest person can feel the limits of biological time.

The centrality of women's experience is that the work associated with subordinated women can mask the demands of biological time and its connectedness to ecological time for dominant men (and women) who claim transcendence over natural boundaries and limits. Thus an ethics from the standpoint of women makes political sense. It is not an essential statement about the *nature* of women or something universally attributable to women. Not all women do women's work and much is done by subordinated men. Women's work represents the immanence of human existence, the non-negotiable needs of the body. Failure to recognize this can lead to the destructive arrogance of claims to transcendence. These dangers are well expressed by Patricia Gunn Allen (1990):

> Walking in balance, in harmony, and in a sacred manner requires staying in your body, accepting its discomforts, decayings, witherings and bloomings and respecting them … Walking in balance requires knowing that living and dying are twin beings, gifts of our mother, the Earth … In the end you can't cheat her successfully, but in the attempt to do so you can do great harm to the delicate and subtle balance of the vital process of planetary being (pp52–53).

Note

1 This essay builds on arguments initially made in my book. *Feminism and Ecology*. See Mellor, 1997b.

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12

Gender and Social Capital: The Importance of Gender Differences for the Maturity and Effectiveness of Natural Resource Management Groups

Olaf Westermann, Jacqueline Ashby and Jules Pretty

Introduction

It is increasingly well established that social capital is an important factor in building and maintaining collective action (Krishna and Uphoff, 1998; Pretty, 2003; Pretty and Ward, 2001; Putnam et al, 1993; Scoones, 1998; Woolcock, 1998), which is in turn fundamental to substantial and long-term changes in natural resource management (NRM) (Agrawal and Gibson, 1999; Baland and Platteau, 1996; Bromley, 1992; Korten, 1986; Ostrom, 1990; Pretty, 2002; Pretty and Smith, 2004; Reddy, 2000; Steins and Edwards, 1999; Wade, 1987). Analysis of causal relationships among improved resource management and collective action has hitherto centred on the existence or creation of appropriate institutional and property arrangements (Bromley, 1992; Leach et al, 1999; Olson, 1965; Ostrom, 1990), but there is an emerging recognition that relations of trust and common values are important to collective action (Harris and Renzo, 1997; Lyon, 2000; Pretty and Ward, 2001; Uphoff, 2000). Particular attention has been given to the concept of social capital, broadly understood as a social resource 'upon which people draw when pursuing different livelihood strategies requiring coordination and collective action' (Scoones, 1998, p8). However, as Krishna (2000) concludes in an analysis of the implications of differences in social capital, little is known about how to tailor programmes to building social capital based on such differences. In this chapter, we argue that the role of gender differences may be of particular importance to understand and create social capital in order to sustain NRM groups. Although the gender dimensions of NRM have been identified as key factors

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shaping peoples access to and use of natural resources (Agrawal, 2000; Cleaver, 1998a; Poats, 2000), most discussion of social capital so far appears to have been almost gender blind (Molyneux, 2002) or even critical toward women's role in the formation and maintenance of social capital (Riddell et al, 2001). Consequently, analysis of gender biases of social capital, understood as collective action that (re)produces gender discrimination, that is, reinforces male dominated power structures and excludes women from participation and decision making, is also almost non-existent. Thus, the hypothesis that gender influences NRM through different, gender-related stocks and usages of social capital requires further examination and empirical testing.

Classifying social capital as 'institutional', based on transactions governed by roles, rules, procedures and organizations or as 'relational', and so governed by norms, values, attitudes and beliefs, suggests that different strategies are needed for building social capital to support collective action for NRM. Krishna (2000, p79) indicates that in situations where relational social capital is strong but institutional capital is weak, collective action interventions will need to introduce rules, procedures and skills to build institutional capital on a relational capital base. Conversely, where rules, procedures, roles and organizations are in place to support collective action, but mutual trust is low and little value is placed on collaboration, interventions will need to build trust and willingness to work together, and create relational social capital (Krishna, 2000, pp80–88). In this paper, we conclude that the distinction between relational and institutional social capital is highly pertinent to understanding the implications of gender differences. Thus, neglect of the gender dimensions of social capital might lead to misleading conclusions about optimal intervention strategies. We investigate the different processes and outcomes in 46 men's, mixed and women's groups in 33 rural programmes in 20 countries of Latin America, Africa and Asia.

Gender, Social Capital, and the Environment

Discussion on the gender aspects of development and environment has its origins in the theories of Women, Environment and Development (WED), which highlight women as having a special relationship with the environment due to their responsibilities for the family and concern for the well-being of future generations (Jackson, 1993; Manion, 2002; Martine and Villarreal, 1997). In this approach, women are seen as 'a transcultural and transhistorical category of humanity with an inherent closeness to nature' (Jackson, 1998, p314) and thus likely to be the principal managers of the environment at local level (Green et al, 1998).

A number of alternative perspectives have also emerged that are less biologically determinist about women's roles in development and environmental management. These include gender analysis (Jackson, 1993), feminist political ecology (Rocheleau, 1995), feminist environmentalist (Agrawal, 1992), and the micropolitical economy of gendered resource use (Leach, 1991). All support the argument that gender differences in NRM are not due to women's inherent closeness to nature but due to 'dynamic and complex gender identities in which men and women experience both shared and divided interests' (Jackson, 1998, p315). According to these authors, gender differences in environmental relations and management should be understood as, and equated with, social relations.

Gender differences in needs and endowments may be key determinants of ways in which men and women manage natural resources. The relationship between women and nature is frequently analysed in terms of the increasing dependency on natural resources poor rural women experience due to poverty. In what has been termed the feminization of poverty, women have been identified as often carrying the main burden of poverty due to the over-representation of female-headed households among the poor who depend more on common pool resources (Jackson, 1993; Martine and Villarreal, 1997). Simultaneously, it has been claimed that the household division of labour and women's responsibility for family provision of household resources such as water and fuelwood makes women both more dependent on common property or open access to natural resources and at the same time more vulnerable to the negative effects on rural livelihoods of resource degradation (Manion, 2002).

Despite the case for viewing gender differences and gender relations as influential in NRM decisions, gender has been largely absent from efforts made to define social capital (Molyneux, 2002; Riddell et al, 2001). However, several studies have found that men and women may have different kinds and qualities of social capital based on differences in their social networks, values of collaboration, levels of conflict and capacity for conflict management. With respect to social networks, a number of researchers have found that women often depend more on informal relations and so form stronger kinship and friendship relations than men, who tend to rely more on formal relationships (Agrawal, 2000; Molyneux, 2002; More, 1990; Riddell et al, 2001). However, structural variables (such as number of children, marital status, age, employment status, income and occupation) can be more important for explaining differences in their social networks than gender (More, 1990).

Molinas (1998) found that successful collective action is dependent on the degree of women's participation. This is consistent with the argument that women exhibit more cooperative behaviour than men due to greater interdependency and altruism (Folbre, 1994; Sharma, 1980; White, 1992). However, Jackson (1993) emphasizes that the assumption of women's greater altruism is evidence of a common failure to scrutinize the private interest of women adequately. Women cannot be seen as a uniform category but a diverse group of people who vary according to class and culture as well as resource endowments and decision making power both between and within households. Molyneux (2002) also criticizes the assumption that women are more altruistic for not questioning the power relations that limit women's participation in formal organizations and so cause women more to rely on informal networks. Hence, the 'naturalization' of women's cooperative behaviour could be abused by targeting women for voluntary 'unpaid' work.

Agrawal (2000, p292) on the other hand, without rejecting possible gender differences in informal relationships and altruism, finds that the key to understanding such gender-differentiated social capital has to be found in the dependency of social networks and value of collaboration as the gender division of labour often obliges women to work in groups. She suggests that

> women have a greater need to build up social capital through localized networks, since women's avenues for accumulating economic resources and their physical mobility is typically more restricted than men's. They also have a greater need to sustain these networks, given their fewer exit options and lesser intra-household bargaining power.

Gender differences in conflictiveness and capacity to resolve conflicts may also reflect power relations that make women more vulnerable than men to the negative effects of conflict. According to several authors (Agrawal, 2000; Cleaver, 1998a, 1998b; Moser and Mcllwaine, 1999), women are often more affected by conflict because they are more dependent on informal networks of collaboration. But Agrawal (2000) suggests that such interdependence helps to overcome social division and to facilitate conflict resolution.

In summary, gender relations have been identified as important determinants of the capacity for collective action for NRM. Gender differences in several aspects of social capital have also been identified or hypothesized, but these two strands of analysis in the literature have not been well integrated. Several important and unanswered questions have practical implications for policy and programme design. To what extent do women and men demonstrate different NRM outcomes based on collective action? Do women tend to build and use social capital more readily than men, and if so, is this associated with gender differences in NRM? Moreover, gender-differentiated social capital may not be inherently beneficial to NRM if social capital upholds or increases exclusion and discrimination. Thus, if gender-differentiated social capital exists, is this due to innate gender-related attributes, the poverty of most rural women, or the underlying differences between men and women in power, influence over decision making, and control over assets? Thus, do NRM interventions relying on collective action for success need to include gender-differentiated strategies for building and using social capital?

In this paper, we analyse the different and complementary roles of women and men in social capital formation and its use, and explore the potential consequences of gender differences for NRM. We bring empirical evidence to bear on some aspects of the questions posed above. The analysis focuses on three broad propositions about the characteristics of gender differences in social capital:

1 Women and men commonly depend on different kinds of social relations or networks (Agrawal, 2000; More, 1990; Neuhouser, 1995). Women are often more dependent on informal networks based on everyday forms of collaboration such as collecting water, fetching fuelwood and child rearing. Such informal networks provide solidarity and access to household resources like water and firewood. Men are often engaged in more formal networks, such as project groups and community councils that improve access to economic resources and decision making (or power) (Agrawal, 2000).

2 Women and men may value collaboration differently. Women often have more everyday experiences of informal collaboration based on reciprocal relationships and higher dependence on social relations for access to household resources (Agrawal, 2000; Cleaver, 1998b). At the same time, it is often assumed that women reveal more relational and altruistic behaviour due to their role and responsibility for reproduction (Folbre, 1994; Sharma, 1980; White, 1992), and are less motivated by selfish individualism (Molyneux, 2002), while men are more individualistic and more engaged in formal collaboration, decision making and organized power structures.
3 Women are better able to overcome social division and conflicts (Agrawal, 2000; Cleaver, 1998b; Moser and Mcllwaine, 1999), because of their greater interdependency and their everyday experiences of collaboration. As a consequence, women are expected to perform better in groups, and – also as a result of their greater dependency on natural resources due to the household division of labour – to achieve better outcomes from collective NRM (Agrawal, 2000).

Framework and Methodology

Examination of the complex causal relationships between gender and collective NRM through different gender-related stocks and usage of social capital requires an innovative three-dimensional framework that combines elements of gender analysis, collective NRM, and social capital based on previous frameworks developed for environmental collective action (Agrawal, 2000; Krishna, 2000; Pretty and Frank, 2000; Pretty and Ward, 2001): The three dimensions employed for our analysis comprise:

1 The effects of gender on social capital based on the three propositions on gendered social capital described above that refer to social relations in networks, collaboration and conflict management.
2 The impact of gender on the effectiveness of collective action measured in terms of the maturity of groups (Pretty and Ward, 2001).
3 The effects of gender on the results of NRM measured in terms of a group's learning approach to NRM (Pretty and Frank, 2000).

Combining these three dimensions of the relationship between gender, collective action and NRM, our analysis assesses five features of collective action in NRM groups: (1) collaboration; (2) social relations in networks; (3) conflict management; (4) group maturity; (5) impact on NRM. Each of these five variables is now defined in detail below.

1 *Collaboration* – defined here in terms of five dimensions: frequency, value, purpose, type and structure of collaboration. To examine the frequency by

which group members collaborate, we examined (i) how often the groups get together for meetings or specific activities and (ii) how often the group's members work together outside the group (by collaboration 'among group members outside the group' we refer to situations where two or more members of the group get together and collaborate on an informal basis on activities that are not necessarily related to the specific objectives of the group). To measure the value placed on collaboration, we analysed the dichotomy between altruism and working for the common good *vs* selfishness and participation for personal benefit. This was measured through respondents' assessment of whether group members participated for the purpose of individual gains (such as resources and higher personal status) and/or whether their main motive of participation was a desire to contribute to group or community benefit. Because such judgement is naturally prone to bias, we have sought to revise the analysis through triangulation of similar issues. These include level of solidarity among group members in situations of emergency or need, as well as group members' specific incentives or purposes of collaboration including access to monetary resources or credit, access to agricultural inputs or land, access to decision making, access to collaboration and mutual help and opportunities to socialize (i.e. psychological benefit of belonging to a group). Based on the three propositions about gender differences in social capital discussed above, we would expect to observe higher values related to collaboration, and higher frequency of collaboration in groups where women are present, and the highest levels of collaboration in women-only groups.

2 *Social relations or networks* – defined here as a set of people (or organizations or other social entities) connected by a set of social relationships (such as kinship, friendship, labour groups) that enable the flow of resources and information through them (Garton et al, 1997). We focus specifically on bonding connections (between individuals in the group) and less on bridging connections (horizontal between the group and other local groups) and linking connections (vertical connections between the group and external organizations). To examine bonding connections, we analysed in-group relationships among individuals dividing them into relational (family, friends and neighbours), functional (cooperatives, community councils and external projects), symbolic (ethnic, religious and political), and place-based relationships (historical and cultural attachment).

3 *Conflict management* – defined here according to the frequency of differences in groups that lead to conflict, and capacity to resolve disagreements. If gender differences influence capacity to manage conflict we should, according to the propositions on gender and social capital and women's capacity to overcome social division and conflict, expect to find fewer incidences of conflict and a higher capacity (from non-existing to very high) to resolve the existing ones among women's groups as compared to men's and mixed groups. This again should coincide with dependency on and values of collaboration previously measured in terms of frequency of collaboration as well as values of altruism and solidarity.

4 Group maturity, here defined as NRM groups' 'potential for self-defining and self-sustaining activity' (Pretty and Ward, 2001, p209), has been operationalized in previous research into a series of criteria which can be found at three levels of development termed reactive dependence, realization independence and awareness interdependence. We measure these stages of maturity on the basis of seven criteria: (i) group objectives in relation to NRM which reflect whether the group is reactive, regenerative or innovative; (ii) the group's views on change (whether avoiding change, adjusting to change, or creating new opportunities); (iii) whether the group monitors and evaluates its own progress; (iv) the degree of reliance on external facilitators to solve problems; (v) collective or individual planning and testing; (vi) the importance of external aid for the formation of the group; and (vii) resilience or likelihood of the group breaking up. Effectiveness or the potential for self-defining and self-sustaining activity is operationalized principally in terms of increasingly supportive values and attitudes toward self-organizing collective action. If there are gender differences in social capital that strengthens internal group relations, then we would expect group maturity to be positively related to the proportion of women in a group.
5 NRM impact is defined here in terms of the management and learning approach to NRM adopted by the groups. The three categories used are (i) reactive (focused on eco-efficiency by reducing cost and environmental harm); (ii) regenerative (adoption of regenerative technologies and some principles of sustainability); (iii) redesign (innovation according to ecological principles, no longer adopting new technologies to fit the old system, but innovating to develop entirely new systems of management). The three categories of NRM are indicators of the evolution of the capacity of a group to engage in a progressively more sophisticated learning process approach to NRM (Argyris and Schön, 1978), and is evinced by a progression along a continuum from remedial measures to changing current practice and ultimately to fundamental innovation (Pretty and Frank, 2000). NRM innovation in a collective action situation requires high levels of trust and networking to promote knowledge sharing and confidence in reciprocal support from the group in the face of risk. If there are gender differences in the stock and usage of social capital, and if these affect innovation in NRM, then we would expect to find that groups with a higher proportion of women have a higher probability of being at the innovation stage in the continuum of NRM.

We examined the NRM outcomes that groups achieved, providing respondents with 12 options from which they could select freely. These options were designed to show whether groups had adopted a reactive or regenerative learning approach to NRM. In this analysis, we could not include options for redesign, as these should be innovative beyond current knowledge. However, respondents had the possibility to describe such novelty in the 'others' category of the questionnaire.

In total, we examined 46 different randomly selected groups (responses received from questionnaires conveyed to more than 500 NRM programmes all over the world) related to 33 programmes working on NRM in 20 countries of Latin America, Africa and Asia (see Appendix A). All groups had at least three years of working experience, and the majority were small groups with less than 50 participants. The programmes were drawn from databases on NRM from the Consultative Group on International Agricultural Research (CGIAR) system wide programme on PRGA, the IDRC MINGA programme, the World Bank, and the University of Essex (Pretty et al, 2003). The groups were concerned with a variety of NRM issues, including agrobiodiversity, agroforestry, coastal resources, food crop production, Integrated Pest Management, irrigation, soil management, and watershed and catchment management besides a number of programmes that work on a variety of multi-purpose activities with the objective to alleviate poverty through sustainable NRM. The groups represent all of the major categories of NRM groups identified by Pretty and Ward (2001) from eight countries in Asia, eight in South America and four in Africa.

The membership of six programmes' groups was solely men, eight were solely women and 32 were mixed. We recognize the difficulties of working with a category like 'mixed groups', in which women's and men's respective degree of participation may vary considerably and in which the exact gender composition of the groups and position of the group members is not explicitly measured by the questionnaire. Thus the 'mixed group' should be seen as a distinct category of group formation, creating different dynamics and providing unique opportunities for participation that are different from purely men's and women's groups. When compared with men-only and women-only groups, these mixed groups represent a phenomenon that allows us to investigate relationships between the presence of women (or men) in groups and overall group behaviour/performance.

In all, the groups in the sample contained some 1015 families, representing an average of 22 members per group. Despite the constraints of sample size, we were able to identify significant differences between some categories (maturity of groups, NRM achievements/approach and homogeneity of groups) and trends in others (frequency of collaboration, solidarity and capacity to manage conflicts).

These groups were surveyed using a questionnaire instrument containing 31 questions divided into the five themes mentioned above. These included (1) collaboration (characterization of the organization of the group, values of collaboration and experience of collaboration outside the group); (2) social capital in networks (local, local–local and local–external connections); (3) capacity to overcome social division and conflict; (4) indicators of the maturity of the group; and (5) NRM achievements and approaches. The questionnaire was prepared for response by key informants who were external programme facilitators (programme directors or workers with email access), and the answers are based on their assessment of types and levels of social capital in the groups and not on evidence of specific actions and relations as experienced by group members themselves. Reliance on a key informant assessment rather than a direct assessment by the people directly involved, that is, in our case, the members of the NRM groups, is a limitation of the data in particular when a subjective and qualitative assessment is involved. To moderate potential biases, we have put emphasis in the analysis on more tangible issues of social capital like frequency of collaboration and number of connections that can easily and objectively be reported by external observers. At the same time, we have avoided going into some of the more intangible aspects of social capital, such as trust and reciprocity that would require an insider perspective.

Another limitation of the study is the relatively small size and varied composition of the sample, which required careful selection of the statistical methods applied and triangulation of different measures. To analyse the data, we used three different statistical methods to determine differences between the groups: (1) frequency distributions of response for women's, men's and mixed groups; (2) Fisher's exact test of association between responses and type of groups; and (3) least significant difference test (LSD test) for women's, men's and mixed groups' averages in cluster of responses.

In order to compare the frequency of response for women's, men's and mixed groups, we have calculated and compared how often women's, men's or mixed groups have chosen a given option on the average. This analysis was conducted for all responses. We used Fisher's exact test to calculate whether the differences in frequency of response for women's, men's and mixed groups are significant. In our case, Fisher's exact test shows significant association when the value $Pr <= P$ is equal or less than 0.05 (95 per cent level of confidence) or when the $Pr <= P$ is equal or less than 0.10 (90 per cent level of confidence). To determine the difference among averages for cluster of responses, we use the least significant difference test, as it is useful for the comparison of five groups or less (we have three). To interpret the results of the LSD test, the LSD value is compared with the observed average differences. Means with the same t grouping letter are not significantly different because their differences are less than the LSD value. The LSD test was used to analyse clusters related to maturity of groups, local connections, types of collaboration outside the group and NRM achievements. Cluster analysis was carried out to analyse the relationship between group composition (women only, men only or mixed) and group maturity. First, multiple correspondence analysis was conducted of the seven variables used to define group maturity to generate scores for each group on dimensions that represent a combination of the proportion of the shared variance, and then cluster analysis of these scores was conducted using Ward's method (SPSS, 1994).

Results from NRM Groups

Similarities between men's, mixed and women's groups

Despite the clear differences in these programmes and their geographic locations, there were many similarities among the groups. With respect to motives for collaboration (altruistic *vs* selfish), no significant differences were detected among men's, women's or mixed groups – a key aspect of relational social capital and of the argument used by some early ecofeminists (Folbre, 1994; Sharma, 1980; White, 1992). We found that in around half of the groups, group members came together for common good and community purpose mainly (50 per cent of the women's groups, 66.7 per cent of the men's groups and 46.9 per cent of the mixed groups), while in approximately one-third of the groups, the majority of group members were collaborating because of the individual benefits such as resources and status they could gain from this. Moreover, 25 per cent of the mixed groups and 12.5 per cent of the women's groups had other reasons for collaboration, emphasizing participation for both selfish and altruistic reasons. This includes sharing of ideas and more sustainable management of natural resources.

More surprisingly, we did not find any evidence that women had stronger informal relations as indicated by kinship, friendship and neighbourhood relations (20 per cent for men's groups, 22.5 per cent for women's groups and 24.4 per cent for mixed groups), despite the well-documented research on social networks that suggests the fact that women have more informal and kinship related networks than men (Agrawal, 2000; More, 1990; Neuhouser, 1995). In general, the LSD test on group member's relationships did not reveal any significant differences among women, men and mixed groups' local connections (relational, functional, symbolic and place-based relations) except for the functional category where men had a significantly higher score than both the women's and mixed groups. However, it is worth noting that the principal relationship for all three groups is place based, which is consistent with the relatively high level of altruism and orientation toward the community by the majority of the groups. At the same time, all groups reported a very high level of cohesion with little likelihood of breakdown even after initial objectives had been fulfilled.

Gender differences in collaboration and solidarity

Although we found no gender differences in the value placed on altruism, the analysis of collaboration identified some gender differences in collaborative behaviour. Comparing frequency of collaboration, women's groups tend to meet more often than men's and mixed groups (Figure 12.1). Half of the women's groups meet on an average 1–2 times a week, much more frequently than the others: 83.3 per cent of the men's groups and 71.9 per cent of the mixed groups meet at most bimonthly. Women's groups also collaborate more frequently outside the group (Figure 12.2). Members of half of the women's groups collaborate on an everyday basis or 1–2 times a week, where only 16.7 per cent do so in men's and 31.3 per cent in mixed groups. Members of half of the men's groups collaborate outside the group only 1–2 times a year.

One explanation for the greater frequency of interaction by the women's NRM groups is revealed by analysis of group members' principal activities for collaboration outside the group (Table 12.1). Women's groups collaborate more on everyday household activities like cooking and child rearing than both men and mixed

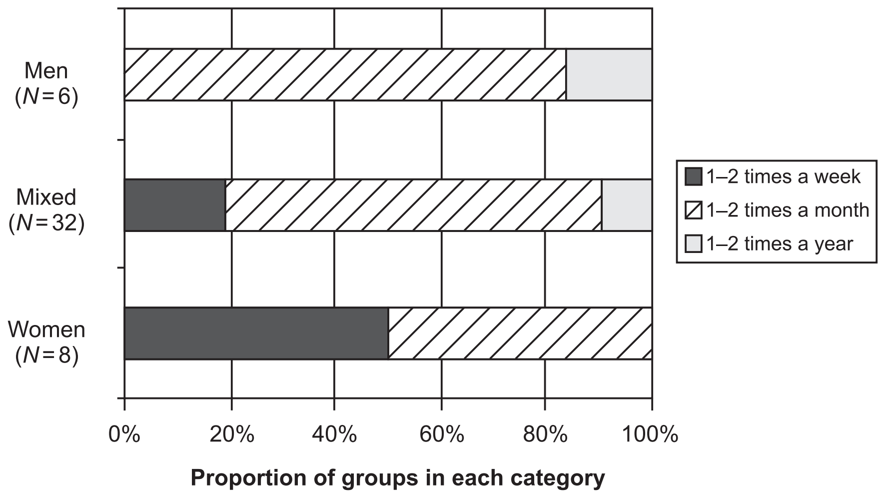

Figure 12.1 *Meeting rate for men's, mixed and women's groups*

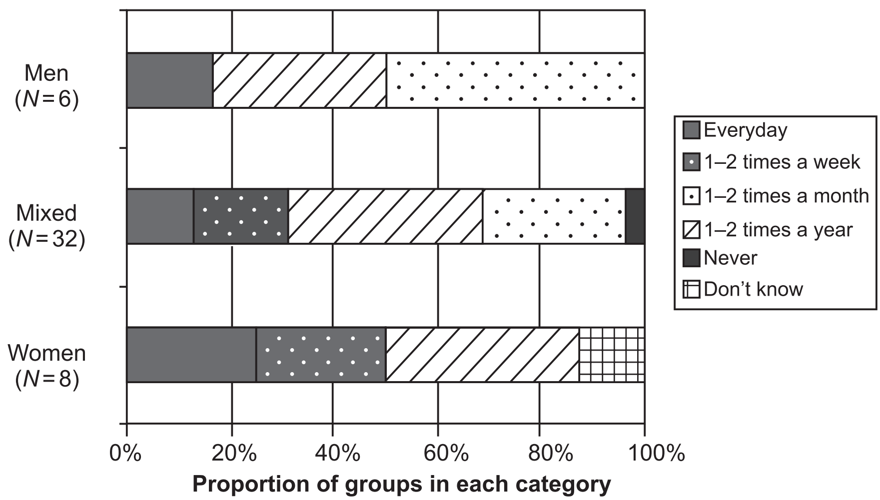

Figure 12.2 *Frequency of collaboration outside the group*

groups. In contrast, men's groups work together on less frequent activities like community infrastructure projects as well as in community boards and in externally facilitated projects. There is no significant difference among the group members' collaboration outside the group over agricultural activities (sowing, weeding and harvesting) and NRM (fetching fuelwood and collecting water). The main purpose of the group for collaboration is to also provide some insight into why women's groups meet more frequently. Access to monetary inputs or credit is the main purpose for meeting for the women groups and tends to be more important

Table 12.1 *Types of collaboration beyond specific group activities*[a]

Type of external collaboration	*Men's (N = 6)*	*Mixed (N = 32)*	*Women's (N = 8)*
Natural resource management (%)	8.3	9.4	0
Household (%)	0	0	31.3
Agriculture (%)	11.1	25.0	20.8
Community infrastructure (%)	33.3	18.7	8.3
Community organization (%)	9.8	7.0	3.1

[a] Least significant differences test for cluster of responses.

to women's groups than to men's groups only or mixed groups (31.3 per cent compared with 16.7 per cent for men's groups and 15.3 per cent for mixed groups) compared with other motivations for collaboration. Credit tends to require a high level of monitoring and turnaround.

Finally, solidarity tends to increase in groups where women are present. A majority of all types of groups report that they always or usually help fellow members in case of emergency, but mixed and women's groups report more solidarity compared to the men's groups: 90.7 per cent of mixed groups and 87.5 per cent of women's groups say they always or usually help fellow group members in case of emergency or need, while 66.7 per cent of men's groups indicate that they do this.

In summary, frequency of collaboration inside and outside the NRM group as well as solidarity is higher in groups including women, and this is mainly associated with collaboration in gender-specific tasks, responsibilities and needs. Our findings do not suggest that collaboration among women is related to the special value they place on altruism.

Gender differences and conflict

Fisher's exact test of the differences among the group shows a significantly higher homogeneity among members of women's groups than men's and mixed groups (37.5 per cent of the women's groups claim not to have significant differences among group members, while the figures for the men's groups and mixed groups are respectively, 0 per cent and 6.3 per cent). On the other hand, our results show no gender differences in the incidence of conflict (50 per cent of both men's and women's groups have no experience of serious conflict), but reported that the capacity to manage conflict tends to be higher in women's groups. Overall, 73.9 per cent of all groups report having demonstrated capacity (medium to very high) to overcome differences and conflict, but where women are present, groups tend to be better at managing conflict (50 per cent of the women's groups have high or very high capacity to manage differences and conflict, while only 33.3 per cent of men's groups and 40.6 per cent of mixed groups do so) (Figure 12.3). However, these results may be biased by the fact that the term conflict and the severity of

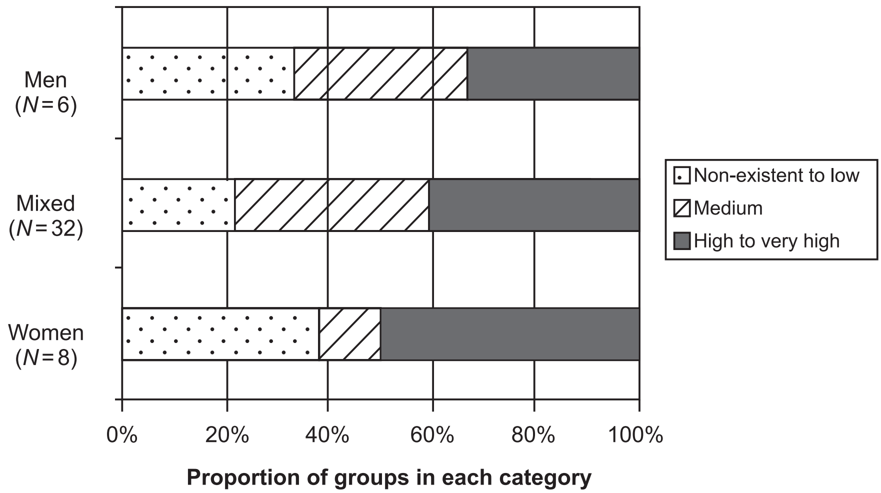

Figure 12.3 *Group capacity to manage conflict*

these could have been interpreted in different ways in the questionnaire. Consequently, respondents may have given their answers based on different understandings of the term 'conflict'.

Gender differences in group maturity

Group maturity refers to the effectiveness of groups to sustain collective action, measured according to seven criteria. Table 12.2 presents the frequencies for men-only, mixed and women-only groups on each of the seven criteria. Overall, men's groups are at an early, realization-independence stage of group maturity. Women's groups, by contrast, have a strong capacity for sustained collective action indicated by the stage of awareness interdependence in group maturity. It is important to note that maturity in this context does not refer to or correlate with age or duration of the group: our analysis also found that women's groups have fewer years of experience (3.9 years) than both the men's (5.3 years) and the mixed (5.7 years) groups. Table 12.2 shows that women's groups are more forward looking in terms of NRM and appear to have less fear of change. Women's groups also conduct self-analysis more regularly, which is consistent with their generally more frequent rate of meetings and collaborative actions. And finally, women's groups more often organize on their own behalf and with less external assistance than both the men and the mixed groups.

The conclusion that the presence of women in groups is likely to increase maturity or capacity for self-defined and self-sustaining collective activity on a long-term basis is supported by the results of the cluster analysis shown in Figure 12.4. Multiple correspondence analysis was carried out with two dimensions that are composites of group type and the criteria in Table 12.2. Dimension 1

Table 12.2 *Proportion of men's, mixed and women's groups measured according to seven criteria in each of three stages of maturity (stage 1: reactive dependent; stage 2: realization independent; stage 3: awareness interdependent)*

Seven criteria measured	*Group type*					
	Men		*Mixed*		*Women*	
	%	*N*	%	*N*	%	*N*
Group objective						
Stage 1: To conserve or restore a natural resource or resources to a previous status (the goal of the group is to restore what once was)	0	0	12.5	4	12.5	1
Stage 2: To adapt to a change in the status of a natural resource or resources (the goal of the group is to adjust to new realities)	66.7	4	46.9	15	12.5	1
Stage 3: To create new opportunities in managing a natural resource or resources (the goal of the group is to introduce something completely new)	33.3	2	40.6	13	75.0	6
Views of change						
Stage 1: The group is fearful of change, it is defensive	0	0	3.1	1	0	0
Stage 2: The group is adjusting to change, it is reactive	50.0	3	46.9	15	12.5	1
Stage 3: The group is creating new opportunities, it is proactive	50.0	3	50.0	16	87.5	7
Self-analysis						
Stage 1: The group has never evaluated its progress in meeting its objectives	16.7	1	0	0	0	0
Stage 2: The group sometimes evaluates its progress in meeting its objectives	66.7	4	59.4	19	25.0	2
Stage 3: The group regularly evaluates its progress in meeting its objectives	16.7	1	40.6	13	75.0	6
Problem solving						
Stage 1: Usually relies on help from outsiders to solve a problem	33.3	2	21.9	7	25.0	2
Stage 2: First tries to solve a problem itself before seeking help from outsiders	33.3	2	71.9	23	75.0	6
Stage 3: The group does not need outside facilitators to solve its problems	33.3	2	6.3	2	0	0
Planning and testing						
Stage 1: Individual planning and testing	16.7	1	12.5	4	0	0
Stage 2: Group planning and then individual testing	66.7	4	40.6	13	62.5	5
Stage 3: Group planning and group testing	16.7	1	46.9	15	37.5	3

Table 12.2 *(continued)*

Seven criteria measured	*Group type*					
	Men		*Mixed*		*Women*	
	%	*N*	%	*N*	%	*N*
Group formation						
Stage 1: Because an external agency asked it to	50.0	3	43.8	14	12.5	1
Stage 2: Because one or more of its members took the initiative and there was external agency support to help it form	33.3	2	43.8	14	50.0	4
Stage 3: Because one of more of the members took the initiative to form the group without external support	16.7	1	12.5	4	37.5	3
Resilience						
Stage 1: It is possible that group breaks down before its goals are achieved	16.7	1	6.3	2	0	0
Stage 2: It is possible that the group breaks down after achievements of initial goals	0	0	21.9	7	28.6	2
Stage 3: It is unlikely that the group breaks down. The purpose of the group is redefined when initial goals are achieved	83.3	5	71.9	23	71.4	5

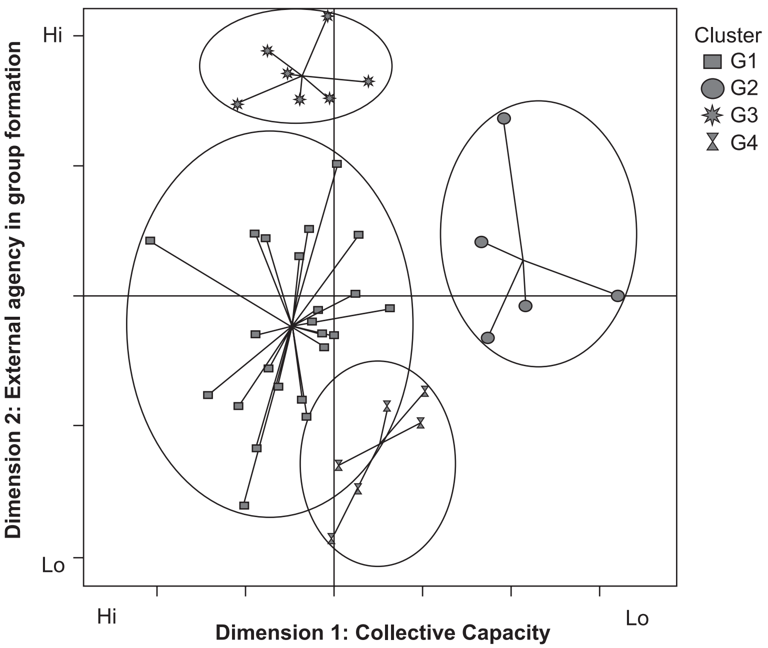

Figure 12.4 *Cluster analysis of group maturity*

represents 'collective capacity' as it is a composite of four variables: independence from external facilitators for problem solving, engagement in group planning and group testing, resilience, and women's presence in group composition. Collective capacity goes down reading from left to right in Figure 12.4. Dimension 2 is predominantly characterized by the variable 'group formation': thus, groups formed because an external agency asked them to do so cluster at the top as shown in Figure 12.4; groups formed without external agency cluster at the bottom. The most important cluster identified is Cluster G1, which is associated with groups formed without external agency. Groups in this cluster have women members; independence from external facilitators; group planning as well as group testing; and are considered unlikely to break down. This cluster is characterized by the presence of women in the groups: it includes all except one of the women-only groups and includes only one of the men-only groups. Cluster G3 differs from G1 in that its groups have been formed by external agency, and includes the one remaining women-only group. Cluster G2 and Cluster G4 consist of most of the men-only groups and are located mainly on the right-hand side of Figure 12.4, showing that collective capacity is lower in these clusters which are characterized by reliance on outsiders to solve problems as well as individual planning or testing.

Gender differences and NRM achievements

Gender differences were identified in the type of NRM achievements reported by the groups. Actual NRM achievements of the groups were classified in terms of their relation to different learning approaches – reactive and regenerative. Women's groups report a significantly higher proportion of regenerative outcomes than men's groups. There is no significant difference among groups in their reactive achievements. This difference among women's and men's groups is consistent with their responses to the survey question designed to elicit which NRM approach the group applies. These findings support the assumption of Pretty and Ward (2001) that NRM learning approach is related to group maturity. We show that the more mature women's groups apply more regenerative measures of NRM compared with the less mature men's groups.

Conclusions and Policy Implications

The analysis of different and complementary roles of women and men in social capital formation and the potential consequences of such differences for collective NRM in this study were guided by the proposition that women tend to build more relational social capital than men, that is, informal social relations and networks based on norms of collaboration and conflict management. The reason for this, it is argued, is that women supposedly value collaboration, altruism and conflict resolution more highly. Gender differences in stocks and use of relational social capital may translate into different NRM outcomes because norms of reciprocity facilitate collective management of natural resources by providing trust. Trust and reciprocity among actors at a personal and generalized level facilitate information exchange (and thus limit transaction costs) and so collaboration needed for collective action is enhanced. Collaboration which values solidarity and generosity may allow access to resources and discourage stakeholders from applying certain management practices that would affect others negatively. Women's relational social capital and values which support solidarity with other women may enable them to organize more effective collective action than men.

Our analysis reveals mixed results in relation to these propositions. On the one hand, propositions about the tendency of women to have altruistic values and informal relationships that endow them with higher social capital than men are not supported by this study. In groups formed for collective action in NRM, we did not find significant gender differences in relational social capital in terms of the reported value placed on altruism and the extent of informal kin relationships. On the other hand, we did find gender differences in the frequency of collaboration, solidarity and capacity to manage conflict where the data reveal an effect on group behaviour of the presence of women in groups. We found that collaboration, solidarity and conflict resolution all increase with women's presence in the groups, which is congruent with Molinas' (1998) and Odame's (2002) finding that women's participation increased cooperation. Our findings suggest that norms of reciprocity are more likely to operate in groups where women are present and that this may be the result of women's work responsibilities that rely on frequent collaboration.

Similarly, the capacity for self-sustaining collective action increased with women's presence and was significantly higher in the women's groups. The analysis demonstrated a significant relationship between (1) maturity of groups and gender and (2) NRM approaches/achievements and gender characteristics of groups. This result supports the finding from another study that maturity of groups is positively related to performance and management of natural resources (Pretty, 2003; Pretty and Ward, 2001). At the same time, we would be cautious about concluding that a more regenerative approach to NRM found in women's groups compared with men's more reactive approach is a direct result of higher awareness of ecological principles. This situation more likely reflects women's potentially higher dependency on common property resources and their limited access to external inputs.

The analysis provides clear evidence of the vital role of gender analysis for collective NRM and points to the importance of diagnosing gender differences in social capital in a community or a group before intervention in order to match the existing level of social capital with the need to organize for specific collective activities. It does not make sense to assume that women will automatically possess a higher stock of social capital than men. It will be important to examine how different gender-related needs, responsibilities and endowments, and in particular the gender division of labour, affect commitment to norms of reciprocity and collaboration.

However, we recommend careful analysis of the potentials for the spillover effect of gender-differentiated social capital in order to identify ways of taking advantage of the existing levels of social capital to strengthen the organization of collective NRM. Such an analysis must pay ample attention to the private interest of women and should consider whether and how collective action represents a resource from which different types of classes of women will benefit in different ways. Specifically, it will be important not to exploit women's potential for collective action to implement NRM projects that are not in their direct interest and to avoid reinforcing the 'dark side' of gender-specific social capital, which may be exclusionary and discriminatory. Women may depend more on some forms of relational social capital simply because they are excluded from male-dominated formal networks and organized power structures where institutional social capital is built and exercised.

Moreover, informal networks are needed to cope with multiple responsibilities for household provisioning, reproduction, child-care and risk management. Women's capacity for organizing effective collective action may not be related to, or depend on gender differences in the values, attitudes and informal relations that constitute relational social capital but on their opportunity for participation and even the sheer pressure of their workload. Based on the finding that mixed groups are an important type of organization where women's presence has an effect on group performance, we would rather suggest that attention should be exercised in forming and supporting mixed groups to ensure that women are given both a clear voice and decision making power. In mixed groups, women and men are likely to have different needs, capabilities and preferences, and to the extent that these differences are respected the presence of women in mixed groups is likely to raise the level of maturity and solidarity in the groups and so improve NRM outcomes. This would imply that an important focus of gender-sensitive capacity building and interventions to promote collective action would be to ensure that there is appropriate opportunity for women to participate.

Consequently, we recommend that interventions to promote collective action for NRM directly address the gender composition of group organization, and in particular the groups' relational and institutional social capital, and any norms, rules or networks that exclude women from participation and decision making. Such a recommendation necessarily implies readiness to challenge the structural positions from which women participate. To do so, it is critical to diagnose the power relations among men and women and comprehend their patterns of interdependence to be able to influence and facilitate gender relations and dynamics in collective action groups. Likewise, it is essential to assess the meaning of participation to women and men and understand better the dynamics and processes of how they draw on collective action resources in gender-differentiated groups.

Further research could usefully examine these issues to flesh out the dynamics underlying our finding that the presence of women in NRM groups tends to increase their effectiveness. Based on our results, we suggest that understanding gender relations is important for the sustainability of groups and how they may improve NRM. Krishna's question about how to tailor programmes to build collective action based on recognition of gender differences in social capital remains unanswered by our analysis. However, one implication of our findings is that in cases where women are high on relational social capital as our analysis revealed, but weak on institutional social capital, and where men have strong institutional social capital but are short of relational social capital, their capacity to organize effective group processes for collective action in NRM will vary. Gender differences in social capital imply that some form of intervention is required to construct institutional social capital in the form of enforceable rules, procedures and sanctions that can be used by women, or alternatively that relational capital is built in the form of enhanced trust, norms of collaboration and conflict management for men. Thus, we conclude that capacity building and interventions to promote collective action for NRM need to be gender differentiated.

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Appendix A. Programme inventory

Agrobiodiversity	
Strengthening the Scientific Basis for In Situ Agricultural Biodiversity Conservation on Farm	Vietnam
Community based Biodiversity Development and Conservation of Indigenous Vegetables of Kenya through Sustainable Use	Kenya
Incorporation of the Chain of Users of Potato in the Participatory Improvement Program	Ecuador

Agroforestry	
Conservation of Medicinal and Aromatic Plants for Sustainable Livelihood	Nepal
Combining Ecological Knowledge and Socio-Economic Perspectives in the Participatory Improvement of Multistrata Agroforestry Systems at the Forest Margin	Indonesia
Coastal resources	
Programa Ecoplata: Apoyo a la Gestión Integrada de la Zona Costera Uruguaya del Río de la Plata	Uruguay
la Marginalización de las Comunidades Costeras	Mexico
Food crop production	
Whole Family Training in Maize,	Bangladesh
Local Committee for Agricultural Research (CIAL Spanish Acronym)	Colombia
Accelerating Adoption of Zero Tillage in Rice-Wheat Systems in the Indo-Gangetic Plains	Nepal and Pakistan
Risk Management Project	Zimbabwe
Revaluation of Native Potato Varieties with Emphasis on Gender in High-Risk Climatic Zones in Ayllu Chullpas	Bolivia
Linking the Formal and Informal Systems: Exploring the Potential for Crop Development and Biodiversity Enhancement	China
Improved Irrigation and Productivity for Organic Aromatic Herbs Farmers in the Provinces of Sihuas y Pomabamba, Department of Ancash	Peru
Integrated Pest Management	
Motivating Farmers to Reduce Insecticide Use	Philippines and Vietnam
Integrated Management of Potato Pests: Refining and Implementing Local Strategies through Farmer Field Schools. The Case of San Miguel	Peru
Desarrollo Agrícola de la Población Indígena de la Zona de Influencia de Mitú – Monfort (Vaupés): Control de Pudriciones en Yuca Mediante Investigación Participativa	Colombia
Irrigation	
Farmer Managed Irrigated Agriculture in Sindh Province	Pakistan
Multiple purpose	
Sustainable Improvement of Marginal Lands in Lebanon: Aarsal, a Case Study	Lebanon
Mainstreaming Marginalized and Disadvantaged Community through Gender and Developmental Activities in Morang District	Nepal
Apoyo la Familias de Baja Renta de la Región Semi-Árida del Estado de Sergipe	Brazil
Participatory Rural Development Project	Nepal
Manejo de Recursos Naturales en la Sierra sur del Perú – MARENASS	Peru

Productión Sostenible de Flores de Anturios Como Alternativa de Diversificatión, Conservatión y Paz Para la Mujer Rural en el Municipio de Caldono Cauca	Colombia
Diseño e Implementatión Participativos de un Prototipo de Reconversión de Fincas a la Productión Sostenible de Hortalizas en el Municipio de Cota, Cundinamarca	Colombia
Developing Effective Institutions for Sustainable Natural Resources Management in Deduru Oya River Basin	Sri Lanka
Soils management	
Integrated Soil Productivity Initiative through Research and Education	Uganda
Control de Erosión de la Micro-cuenca Toralapa Alta – Tercera Fase	Bolivia
Alternativas Para la Recuperatión de Suelos Degradados en Zonas de Ladera del Departamento del Valle del Cauca	Colombia
Watershed and Catchment Management	
Mainstreaming of Gender Concerns in Village Panchayats	India
Participatory Innovation Development in Chivi	Southern Zimbabwe
Support Programme for the Recovery of the San Roque Lake Watershed	Argentina
Regional Development Plan for the Chicamocha River Watershed	Colombia

13

Social Capital and the Collective Management of Resources

Jules Pretty

From Malthus to Hardin and beyond, analysts and policy makers have widely come to accept that natural resources need to be protected from the destructive, yet apparently rational, actions of people. The compelling logic is that people inevitably harm natural resources as they use them, and more people therefore do more harm. The likelihood of this damage being greater where natural resources are commonly owned is further increased by suspicions that people tend to free-ride, both by overusing and underinvesting in maintaining resources. As our global numbers have increased, and as incontrovertible evidence of harm to water, land and atmospheric resources has emerged, so the choices seem to be starker. Either we regulate to prevent further harm, in Hardin's words (Hardin, 1968), to engage in mutual coercion mutually agreed upon, or we press ahead with enclosure and privatization to increase the likelihood that resources will be more carefully managed.

These concepts have influenced many policy makers and practitioners. They have led, for example, to the popular wilderness myth (Nash, 1973) – that many ecosystems are pristine and have emerged independent of the actions of local people, whether positive or negative. Empty, idle and 'natural' environments need protection – both from harmful large-scale developers, loggers and ranchers, as well as from farmers, hunters and gatherers (Callicott and Nelson, 1998). Since the first national park was set up at Yellowstone in 1872, some 12,750 protected areas of greater than 1000 hectares have been established worldwide. Of the 7322 protected areas in developing countries, where many people rely on wild resources for food, fuel, medicine and feed, 30 per cent covering 6 million km^2 are strictly protected, permitting no use of resources (Pretty, 2002).

The removal of people, often the poorest and the indigenous (Posey, 1999), from the very resources on which they most rely has a long and troubling history, and has framed much natural resource policy in both developing and industrialized countries (Gadgil and Guha, 1992). Yet common property resources remain

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immensely valuable for many people, and exclusion can be costly for them. In India, for example, common resources have been estimated to contribute some US$5 billion yr^{-1} to the income of the rural poor (Beck and Naismith, 2001).

An important question is: could local people play a positive role in conservation and management of resources? And if so, how best can unfettered private actions be mediated in favour of the common good? Though some communities have long been known to manage common resources such as forests and grazing lands effectively over long periods without external help (Ostrom, 1990), recent years have seen the emergence of local groups as an effective option instead of strict regulation or enclosure. This 'third way' has been shaped by theoretical developments both on governance of the commons and on social capital (Ostrom et al, 2002; Singleton and Taylor, 1992). These groups are indicating that, given good knowledge about local resources, appropriate institutional, social and economic conditions (O'Riordan and Stoll-Kleeman, 2002), and processes that encourage careful deliberation (Dryzek, 2000), then communities can work together collectively to use natural resources sustainably over the long term (Uphoff, 2002).

Social Capital and Local Resource Management Groups

The term social capital captures the idea that social bonds and norms are important for people and communities (Coleman, 1988). It emerged as a term following detailed analyses of the effects of social cohesion on regional incomes, civil society and life expectancy (Putnam, 1993, 2000; Wilkinson, 1999). As social capital lowers the transaction costs of working together, it facilitates cooperation. People have the confidence to invest in collective activities, knowing that others will also do so. They are also less likely to engage in unfettered private actions with negative outcomes, such as resource degradation (Pretty and Ward, 2001; Agrawal, 2002). Four features are important: relations of trust; reciprocity and exchanges; common rules, norms and sanctions; connectedness in networks and groups.

Relations of trust lubricate cooperation, and so reduce transaction costs between people. Instead of having to invest in monitoring others, individuals are able to trust them to act as expected, thus saving money and time. But trust takes time to build, and is easily broken. When a society is pervaded by distrust or conflict, cooperative arrangements are unlikely to emerge (Wade, 1994). Reciprocity increases trust, and refers to simultaneous exchanges of goods and knowledge of roughly equal value, or continuing relationships over time (Coleman, 1988; Putnam, 1993). Reciprocity contributes to the development of long-term obligations between people, which helps in achieving positive environmental outcomes.

Common rules, norms, and sanctions are the mutually agreed upon or handed-down drivers of behaviour that ensure group interests are complementary with those of individuals. These are sometimes called the rules of the game (Taylor, 1982), and give individuals the confidence to invest in the collective good. Sanctions ensure that those who break the rules know they will be punished. Three types of connectedness (bonding, bridging and linking) have been identified as important for the networks within, between and beyond communities (Woolcock, 2001). Bonding social capital describes the links between people with similar objectives and is manifested in local groups, such as guilds, mutual-aid societies, sports clubs and mothers' groups. Bridging describes the capacity of such groups to make links with others that may have different views, and linking describes the ability of groups to engage with external agencies, either to influence their policies or to draw on useful resources.

But do these ideas work in practice? First, there is evidence that high social capital is associated with improved economic and social well-being. Households with greater connectedness tend to have higher incomes, better health, higher educational achievements, and more constructive links with government (Pretty, 2002; Ostrom et al, 2002; Putnam, 1993; Wilkinson, 1999; Krishna, 2002). What, then, can be done to develop appropriate forms of social organization that structurally suit natural resource management?

Collective resource management programmes that seek to build trust, develop new norms and help form groups have become increasingly common, and are variously described by the terms community-, participatory-, joint-, decentralized- and co-management. They have been effective in several sectors, including watershed, forest, irrigation, pest, wildlife, fishery, farmers' research and micro-finance management (Table 13.1). Since the early 1990s, some 400,000–500,000 new local groups were established in varying environmental and social contexts (Pretty and Ward, 2001), mostly evolving to be of similar small size, typically with 20–30 active members, putting total involvement at some 8–15 million households. The majority continue to be successful, and show the inclusive characteristics identified as vital for improving community well-being (Flora and Flora, 1993), and evaluations have confirmed that there are positive ecological and economic outcomes, including for watersheds (Krishna, 2002), forests (Murali et al, n.d.) and pest management (Pontius et al, 2001).[1]

Further Challenges

The formation, persistence and effects of new groups suggests that new configurations of social and human relationships could be prerequisites for long-term improvements in natural resources. Regulations and economic incentives play an important role in encouraging changes in behaviour, but although these may change practices, there is no guaranteed positive effect on personal attitudes (Gardner and Stern, 1996). Without changes in social norms, people often revert to old ways when incentives end or regulations are no longer enforced, and so long-term protection may be compromised.

However, there remains a danger of appearing too optimistic about local groups and their capacity to deliver economic and environmental benefits, as divisions within and between communities can result in environmental damage. Moreover not all forms of social relations are necessarily good for everyone. A society may have

Table 13.1 *Social capital formation in selected agricultural and rural resource management sectors (since the early 1990s)*

Countries and programmes	*Numbers of local groups (thousand)*
Watershed and catchment groups	
Australia (4500 Landcare groups containing about one-third of all farmers), Brazil (15,000–17,000 microbacias groups), Guatemala and Honduras (700–1100 groups), India (30,000 groups in both state government and NGO programmes), Kenya (3000–4500 Ministry of Agriculture catchment committees), US (1000 farmer-led watershed initiatives)	54–58
Irrigation water users' groups	
Sri Lanka, Nepal, India, Philippines, Pakistan (water users groups as part of government irrigation programs)	58
Microfinance institutions	
Bangladesh (Grameen Bank and Proshika), Nepal, India, Sri Lanka, Vietnam, China, Philippines, Fiji, Tonga, Solomon Islands, Papua New Guinea, Indonesia and Malaysia	252–295
Joint and participatory forest management	
India and Nepal (joint forest management and forest protection committees)	35
Integrated pest management	
Indonesia, Vietnam, Bangladesh, Sri Lanka, China, Philippines, India (farmers trained in farmer field schools)	18–36

Note: This table suggests that 417,000–482,000 groups have been formed. Additional groups have been formed in farmers' research, fishery and wildlife programmes in a wide variety of countries.

Source: See Pretty and Ward, 2001

strong institutions and embedded reciprocal mechanisms yet be based on fear and power, such as feudal, hierarchical and unjust societies. Formal rules and norms can also trap people within harmful social arrangements, and the role of men may be enhanced at the expense of women. Some associations may act as obstacles to the emergence of sustainability, encouraging conformity, perpetuating inequity, and allowing certain individuals to shape their institutions to suit only themselves, and so social capital can also have its 'dark side' (Portes and Landolt, 1996).

Social capital can help to ensure compliance with rules and keep down monitoring costs, provided networks are dense, there is frequent communication and reciprocal arrangements, small group size and lack of easy exit options for members. However, factors relating to the natural resources themselves, particularly whether they are stationary, have high storage capacity (potential for biological growth), and clear boundaries, will also play a critical role in affecting whether social groups can succeed in keeping the costs of enforcement down and ensuring positive resource outcomes.

Communities, also, do not always have the knowledge to appreciate that what they are doing may be harmful. For instance, it is common for fishing communities to believe that fish stocks are not being eroded, even though the scientific evidence indicates otherwise. Local groups may have the support of higher-level authorities, for example with legal structures that give communities clear entitlement to land and other resources, and insulation from the pressures of global markets (Ostrom, 1990; Ostrom et al, 2002). For global environmental problems, such as climate change, governments may need to regulate, partly because no community feels it can have a perceptible impact on a global problem. Thus effective international institutions are needed to complement local ones (Keohane et al, 1993).

Nonetheless, the ideas of social capital and governance of the commons, combined with the recent successes of local groups, offer routes for constructive and sustainable outcomes for natural resources in many of the world's ecosystems. To date, however, the triumphs of the commons have been largely at local to regional level, where resources can be closed access, and where institutional conditions and market pressures are supportive. The greater challenge will centre on applying some of these principles to open access commons and worldwide environmental threats, and creating the conditions by which social capital can work under growing economic globalization.

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Notes

1 See the following websites for more data and evaluations on the ecological and economic impact of local groups:
   (a) Sustainable agriculture projects – analysis of 208 projects in developing countries in which social capital formation was a critical prerequisite of success: http://www2.essex.ac.uk/ces/ResearchProgrammes/subheads4foodprodinc.htm. See also Pretty et al, 2003.
   (b) For joint forest management (JFM) projects in India: for impacts in Andhra Pradesh, including satellite photographs, see http://www.ap.nic.in/apforest/jfm.htm. For case studies of JFM, see http://www.teriin.org/jfm/cs.htm and http://www.iifm.org/databank/jfm/jfm.html. See also Murali et al, n.d.; Murali et al, 2003.
   (c) For community IPM, see http://www.communityipm.org/, and Pontius et al, 2001.
   (d) For impacts on economic success in rural communities, see Narayan and Pritchett, 1976. http://poverty.worldbank.org/library/view/6097/. See also Donnelly-Roark and Xiao, n.d., at http://poverty.worldbank.org/library/view/13137
   (e) For Landcare program in Australia, where 4500 groups formed since 1989, see http://www.landcareaustralia.com.au/projectlist.asp and http://www.landcareaustralia.com.au/FarmingCaseStudies.asp

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14

Still Going: Recent Debates on the Goldschmidt Hypothesis

Linda M. Lobao, Michael D. Schulman and Louis E. Swanson

Goldschmidt's (1978a) 1940s study of two California communities generated the hypothesis that large-scale farming has detrimental impacts while family-operated farms enhance community well-being. Research on the Goldschmidt hypothesis has gone through phases corresponding to transformations in the sociology of agriculture and broader rural sociology. This article discusses the present status of the Goldschmidt literature with a focus on a recent article by Barnes and Blevins (1992), which ignored the body of literature generated in the latter phase of the Goldschmidt debate. The result is that their article is premised upon discovering solutions to problems addressed even a decade earlier. However, as Barnes and Blevins (1992) once again raise interest in the Goldschmidt hypothesis, they provide a reason for stepping back and assessing what has been accomplished. Because all of us have participated in the discussion of the Goldschmidt debate, our commentary will draw particularly from our own research.

Goldschmidt's (1978a) *As You Sow* has become a requisite citation for research on rural well-being and economic structure. Early literature reflected numerous quantitative attempts to replicate and test the original hypothesis. By the mid-1980s, however, both the spatial and temporal generalizability of the Goldschmidt thesis were seen as limited. A new generation of researchers recast the Goldschmidt debate in light of post-war transformations of the farm and broader non-farm rural economy (Buttel et al, 1988; Flora and Flora, 1988; Gilles and Dalecki, 1988; Lobao, 1990; Lobao and Schulman, 1991; MacCannell, 1988; Skees and Swanson, 1988; Swanson, 1982; van Es et al, 1988). Theoretical extensions and methodological inroads were made as well. Barnes and Blevins (1992) point to the need to take stock of the new generation of research. In ignoring much of this body of literature, Barnes and Blevins (1992) repeat earlier critiques, discount methodo-

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logical and conceptual issues raised by current researchers, and recover old ground regarding the Goldschmidt thesis.

The Goldschmidt Hypothesis

During the Depression, social scientists observed a new round of farm restructuring that differed from previous eras. This was manifest in the transformation and general decline of simple commodity production, the exodus of poor and tenant farmers from the South, and growth in the West of large-scale, hired-labour-dependent farming. The effects of this latter type of farming and the fear that it would replace traditional family farming were of particular concern to Goldschmidt (1978a) and others (Tetreau, 1938, 1940) who left less notable accounts. As Bertrand (Wimberley, 1991, p24) noted:

> We have sort of overlooked the studies that were done in the '30s as a result of the … disasters in Oklahoma and some of the dust bowl states. There was a lot of work that was sponsored at that time … [Paul] Taylor over in California made studies of the workers on the big fields and the social power mustered by the big owners, you know, put rural sociology completely out of the California university system.

Though others investigated similar issues, Goldschmidt's hypothesis that a trend towards large-scale farming and a concomitant decline of family farming jeopardize community well-being would become the paramount statement of the problem.

Because of the profound political implications of the topic and partly because of Goldschmidt's own lack of clarity, the notoriety of Goldschmidt's (1978a) study has persisted. For supporters, it represents a compelling defence of traditional family farming and assailment of corporate farming (Rodefeld, 1974; Strange, 1988; see also Goldschmidt's subsequent study, 1978b). Critics charge that it provides theoretical justification for neo-populist stances in rural sociology (Friedland, 1989). Economists have challenged its methodology, subjecting it to standards beyond those of the typical case study (Hayes and Olmstead, 1984). Goldschmidt's own lack of clarity as to the causal mechanisms by which farming affected communities undoubtedly contributed to the debate and numerous attempts to replicate this study. As has been long noted, whether Goldschmidt viewed scale or class position or both as central causal elements remains unclear (Goss and Rodefeld, 1979; Green, 1985). Swanson (1990) pointed out, however, that the concordance between scale and position is an empirical question: there is no reason why a growth in large-scale farming must be accompanied by a change in class structure. While this relationship has been observed in California, it has not been confirmed in the Midwest.

Looking Backward

Barnes and Blevins (1992) neglect much of what has been accomplished in the Goldschmidt debate. As a consequence, dated arguments are repeated and the analysis is subject to conceptual and methodological problems found in older studies. A brief review of the early Goldschmidt literature, its documented limitations, and the resulting new generation of studies provides a context to understand our critique of Barnes and Blevins.

The 1970s to early-1980s period

The 1970s through the mid-1980s represents an essentially knowledge-building and largely empirical phase in the Goldschmidt literature. In general, studies focus on replicating and testing Goldschmidt's hypothesis (Leistritz and Ekstrom, 1986). Different methodologies, regional contexts, and dependent variables or indicators of well-being are used to test essentially the same relationship: the effects of large-scale, hired-labour-dependent farming on communities and rural people. Specific studies and salient characteristics of this are summarized elsewhere and noted briefly here (Lobao, 1990; Swanson, 1990).

The purpose of most studies is to examine indicators of one or both farm concepts – scale (sales or acreage) and organization. The latter taps off-farm or non-family dependence on production factors and includes concepts such as land tenure, extent of hired labour use, managerial control and capital use. The studies conceptualize relationships in a generally linear manner, contrasting the effects of large as opposed to small farms. For example, they hypothesize that the larger the farm and/or the greater use of hired labour, the more negative the impact on well-being. Most research is limited to particular regional contexts. Findings are not directly comparable because of the different geographic settings, time periods and methodologies. Studies are mainly empirically driven, aimed at testing the effects of large-scale farming but not at drawing out conceptually why such effects may be expected. Conclusions are framed in simple defence or support of Goldschmidt rather than in recognizing the complexity of relationships that determine community well-being.

On balance, studies of this period tend to support Goldschmidt but few do so unequivocally. One of the first deviations recognized was that results depended upon the indicator of farm structure: larger-scale farming was not found to be related to poorer conditions in several studies (Flora et al, 1977; Harris and Gilbert, 1982; Swanson, 1982). Findings also diverged for other reasons, including the time period, whether well-being outcomes were measured by economic or non-economic indicators, regional location, unit of analysis and the modelling or shape of relationships (Lobao, 1990).

The mid-1980s to present: Critique and response

By the late 1980s, analysts recognized a series of problems with earlier studies that prevented closure on the Goldschmidt debate. A summary of these, with citations if previously made by other authors, is provided in Lobao (1990). 'The first problem concerns the conceptualization and measurement of farm structure. Researchers are often unclear about what aspects of farm structure (scale or organization) are relevant for assessing socioeconomic impacts' (Lobao, 1990, p67). Another issue is the adequacy of control variables for 'agricultural dependency, urbanization, or industrial activity … studies that delineate and control for nonfarm factors are needed to more rigorously test the impact of farm structure' (Lobao, 1990, p66). 'A further methodological criticism … involves the scope of the studies. Most have been confined to areas with specific types of agriculture which limits generalizability of findings. Only a few studies have examined the effects of farm structure for the entire United States' (Lobao, 1990, pp66–67).

Two years later, Barnes and Blevins (1992, p333) reached the same conclusions. They stated:

> First, there are problems with the conceptualization of farm structure. Second, most researchers fail to incorporate indicators of nonfarm structure into their studies. Third, most researchers lump together all nonmetropolitan counties. Finally, almost all existing research is restricted to selected states or regions.

Barnes and Blevins (1992), however, provide no citations as to the sources of these critiques, apparently believing that they are original.

By the late 1980s, other critiques that bear upon the Barnes and Blevins (1992) article had emerged, including those by Swanson (1988b, 1990) and Lobao (1990). Most studies are cross-sectional rather than longitudinal and thus cannot offer direct causal evidence about the impacts of change, nor whether farm change creates short-term or permanent imbalances in a community. There is also a tendency to view the relationship between farm and non-farm variables linearly. Smaller farms are thus presumed to be most beneficial. Causality is mainly one-way. Changes in farm structure are examined as independent variables or causes rather than effects of non-farm community structure. Finally, there are conceptual and theoretical limitations (Lobao, 1990). Researchers neglect to go beyond the original relationships set forth by Goldschmidt. This inhibits the development of a theoretical explanation of how farm change and broader restructuring of the rural economy affect well-being.

By 1990, two volumes of research as well as a number of journal articles had addressed these critiques. The Office of Technology Assessment (OTA) of the US Congress commissioned a series of studies on the effects of farm structure on community well-being that were subsequently published in Swanson (1988a). The studies focus on five regions (North-east, South, Midwest, Great Plains, West) and the highly industrialized farming states of California, Arizona, Texas and Florida.

The authors describe changes in post-war farming patterns typical of each region, then examine the effects of these changes on indicators of county well-being generally for the 1970–1980 period (Buttel et al, 1988; Flora and Flora, 1988; MacCannell, 1988; Skees and Swanson, 1988; van Es et al, 1988).

Also by the mid-1980s, two US Department of Agriculture regional research projects (S-198, S-246) centred on the changing structure of agriculture and its effects on communities. As part of these projects, Wimberley (1986, 1987) developed indicators of agricultural structure from a factor analysis of census agriculture data. His purpose was to describe empirically the changes that had occurred in post-war agriculture but that could not be captured through the use of single indicators of farm structure. To describe national patterns of farming, he created indexes for all counties with census-reported farming, the criteria generally being ten or more farms. While the vast majority (more than three-quarters) of these counties are non-metropolitan, Wimberley (1986, 1987) purposefully did not exclude any metropolitan counties for which farming was reported. Such counties typically contain highly capitalized operations that reflect important present and future structural trends. Wimberley found three dimensions of farm structure that correspond to post-war dualistic tendencies noted empirically and theoretically in the literature – small, part-time farming; highly capitalized, family-labour farming; and commercial-scale, hired-labour-dependent farming. Lobao (1990) employed Wimberley's indicators in a national study of socioeconomic inequality across counties. She viewed differences in local well-being as a consequence of economic structure (farm and non-farm), the power of workers and their households vis-à-vis employers, and spatial or locational characteristics. She also examined the extent to which generalized, national patterns hold for various regions. As most of the sample counties are non-metropolitan, and as a subsequent study (Lobao and Schulman, 1991) showed that the relationships stay the same when the few metropolitan counties are excluded, the study has particular policy implications for rural areas.

With regard to the relationship between farm structure and well-being, the OTA (Swanson, 1988a) and Lobao (1990) studies stated that their aim was to address the limitations of earlier studies. As a consequence, they focused on developing empirical indicators in accordance with their conceptualization of farm structure, Lobao (1990) through the use of Wimberley's (1986, 1987) indicators and the OTA studies through attention to specific regional patterns. Both sets of studies examined non-linear relationships under the assumption that the effects of moderate-size, family-operated farms may vary from those of larger and smaller farms. Non-farm economic structure was controlled in the OTA studies by indicators such as the percentage of the population employed in services and manufacturing. Lobao (1990) used segmented economy theory to classify employment into high-wage, low-wage and state sectors and also included an enterprise-size variable. Other non-farm variables known to have important effects on well-being, such as educational levels and ethnicity, were controlled and the net effects of farming versus the non-farm economy were examined.

Farming dependency was employed as a control variable in all these studies. Four of the OTA studies controlled for this contextually by examining counties at different levels of farming dependency (Buttel et al, 1988; Flora and Flora, 1988; MacCannell, 1988; van Es et al, 1988). Lobao (1990) and Skees and Swanson (1988) insert control variables for farming dependency as well as for urban influences.

The studies were premised upon broadening the generalizability of earlier work, geographically and over time. The OTA studies examined the major US agricultural regions while Lobao's (1990) analysis focused on the continental US, major agricultural regions, and select subregions. Cross-sectional and longitudinal relationships were examined, the latter enabling the effects of farm change to be ascertained. Further, the studies recognized the reverse causal relationship – that community changes influence farming.

Finally, the studies go beyond simple empirical replication of the Goldschmidt hypothesis. Their conceptual frameworks build upon political economy and other perspectives in the sociology of agriculture and community development. Lobao's study (1990) addressed theoretically the reasons for inequality across different spatial settings, incorporating structural perspectives from industrial sociology, economic geography and regional science.

With regard to large-scale farming, the OTA studies found negative effects for the California, Arizona, Texas and Florida regions. Effects were mixed for the Great Plains, West and South, where there was some indication that moderate size farms were related to higher well-being. Farm changes had little relationship to well-being in the North-east and Midwest. Lobao's (1990) national findings were that larger, family-labour-dependent units are related to higher well-being over time and cross-sectionally. Smaller family farming was related to poorer conditions, although not necessarily over time. These effects generally held across regions. Nationally, industrialized farming had little effect on well-being cross-sectionally. This varied over time and by region.

In addition to these volumes, other recent studies addressed aspects of the farm well-being relationship. These studies adopted current methodologies, including the use of longitudinal analyses and controls for important non-farm variables (Albrecht, 1992; Gilles and Dalecki, 1988; Lobao and Schulman, 1991). They shared two major foci. Empirically, they were concerned with the context, particularly region, within which relationships occur. From a conceptual-theoretical standpoint, these studies attempted to develop frameworks to understand why farm structure and its effects might vary by geographic context.

The Barnes and Blevins study

This review is not meant to deny that modification and replication of the previous research are not needed. Rather, it is to show that the unique contributions that Barnes and Blevins (1992, p334) purport to make were made years earlier:

> This study examines the relationship between farm structure and well-being. We remedy problems in previous research by carefully selecting our farm structure variables, incorporating indicators of nonfarm sectors, taking into account the extent of each county's farm dependence, and using data on all nonmetropolitan counties.

If these contributions are not original, what does the Barnes and Blevins (1992) article add to the literature? First, they controlled for agricultural dependency in a somewhat different way than previous studies. They used national data and performed analyses for non-metropolitan counties grouped into three levels of dependency. A second difference is their choice of independent variables for non-farm economic structure; they used an earnings rather than an employment measure.

The contributions of the Barnes and Blevins (1992) article thus appear to be largely empirical. It is certainly useful to question the methodology and measures of previous studies – and if the article had been premised on these aims, we would likely have no qualms. However, overlooking the inroads made in the Goldschmidt literature makes the study vulnerable to other problems.

First, unlike other recent studies, Barnes and Blevins (1992) cannot test whether changes in farming are related to poorer well-being over time. Their analysis was cross-sectional rather than longitudinal. Since their focus seemed to be large-scale, hired-labour-dependent farming, this is particularly critical. There is some evidence that the negative effects of such farming, while small, are observable over time not cross-sectionally (Lobao, 1990; see also Gilles and Dalecki, 1988). Second, Barnes and Blevins (1992) failed to control for key non-farm variables, such as ethnicity, unemployment levels and education. These variables are well-known correlates of poverty and median family income and tend to be associated with economic structure (e.g. industrialized farming areas tend to have higher non-white populations). Relatedly, they do not control for the region of the country nor acknowledge how this fits into their findings. For example, Barnes and Blevins (1992) found that the percentage of the population hired as farm labour and large farms are inversely related to poverty for farming-dependent counties. Such counties, however, are located mainly in the Great Plains and Corn Belt (Reimund and Brooks, 1990) where analysts have found less detrimental and sometimes positive impacts of industrialized farming (Flora and Flora, 1988; Lobao and Schulman, 1991; van Es et al, 1988). Midwestern social structural attributes and the greater presence of resident owners (rather than absentee landlords) of large farms have been given as possible explanations for these findings, which conflict with the traditional Goldschmidt hypothesis (Lobao and Schulman, 1991; Swanson, 1990).

At face value, the methodology used by Barnes and Blevins' (1992) study is inadequate for assessing the relationship between farm structure and community well-being. Moreover, one would expect that the analysis would be tilted toward finding no negative impacts of large-scale or hired-labour-dependent farming, given its cross-sectional approach, regional bias, and lack of additional control variables. Now perhaps Barnes and Blevins did address these problems in an earlier but unreported analysis and perhaps their findings still stand. If this is the case, concern with such methodological issues has been so long-standing in the literature that the method for dealing with them should have been discussed.

The study also raises other questions about the analysis and the authors' intent. Barnes and Blevins (1992, p336) assert that they 'wanted to analyze the potentially different impact of farm structure on the well-being of counties with different levels of farm dependency'. If this is the intent, then interaction terms (for farm dependency by the farm structure independent variables) should have been inserted directly into the regression model. A related point concerns their statement that 'there is an important interaction effect between the farm and nonfarm variables' and that this effect can be discerned by examining the amount of variance explained (Barnes and Blevins, 1992, p345). However, interaction does not refer to the increase in an *R*-squared coefficient that one gets by adding additional variables. Interaction effects refer to the idea that the effect of independent variable A on the dependent variable is conditioned by the level of independent variable B. Interaction effects must be tested by adding an interaction term (A × B) and testing for its significance. If the authors believe that there are important interactions in their data, then these should have been tested for appropriately.

In addition to raising methodological questions, there is a more significant problem. The Barnes and Blevins (1992) article does not advance the literature conceptually but rather reflects the earlier, post-war period of research in which analysts simply replicated the Goldschmidt hypothesis. There is little attempt to explain from a theoretical standpoint why the effects of farm structure may vary in different geographic contexts or to extend the topic through adding new literature and insights. Arguments about the need to incorporate non-farm structure and to control for farming dependency are repeated from prior work. Thus, no new ground is covered and research slips back to an earlier era.

New Directions: Whither the Goldschmidt Hypothesis?

Goldschmidt's (1978a) work has achieved a status seldom accorded other research. The case study of Arvin and Dinuba has taken on mythic proportions and some studies treat the relationships as if set in stone. Over a decade of research has shown, however, that Goldschmidt's hypothesis cannot be applied unconditionally across different regional and historical settings. It is now also well-known that researchers must acknowledge how the structure of agriculture and the factors that shape well-being have changed over time. The literature in the Goldschmidt tradition appears to be exhausting itself, particularly if one looks at the proliferation of studies and regional research projects in the late 1970s–early 1980s as compared with the present. Rather than resurrecting old debates, researchers should focus on the more significant questions raised by the Goldschmidt (1978a) study. How are economy and society linked? What do changes in the economy mean for rural areas and people? What type of agricultural system best serves social needs? These questions cannot be answered by focusing on monolithic generalizations assumed to exist in all times and places.

There are a number of directions in which future studies concerned with the impacts of farming might proceed. Analysts have already carved out some of these directions more deeply than others. The first is the continued elaboration of the relationship between farming structure and community well-being. Case studies to delineate the routes by which farming affects communities are still needed. A thorough analysis of this issue is generally not possible through the use of conventional county-level secondary data. For example, large-scale farming may impact communities through the labour force it utilizes, owners' control of local politics, land and water rights, and environmental regulations. Focusing on the spatial context within which relationships occur and documenting theoretically the reasons for these are another route. Analysts have stressed both environment and social structure as explanations for regional and other geographic differences but further work remains.

A second direction would be to incorporate a focus on farm structure more fully into the general issue of rural and global restructuring (Marsden et al, 1990). This would involve the use of literature from industrial sociology, economic geography and regional science dealing with economic structure and geographic space. This literature covers topics such as the spatial division of labour or distribution of economic activity, labour-market and locality research, and industrial location theory. It could provide insights about the spatial patterns, dynamics, and impacts of farming and how farming articulates with the non-farm economy. Farming would be treated less as a unique case in community economic development, its analysis subject to the principles that govern other industries in the formal and informal economy.

Another direction is to continue to connect changes in farming to broader agricultural issues and to impacts beyond the locality, as others have argued (Friedland, 1982, 1989; Friedland et al, 1981). In the first instance, how farming is affected by and utilized in globalization processes shaping agriculture is a timely issue. While researchers have long pursued the environmental, food safety and health-related impacts of farm production, much of the literature remains dominated by non-social scientists.

Finally, the evolution of the Goldschmidt debate itself is still a largely unexplored topic, barely covered in this commentary. A more systematic review of the Goldschmidt literature, particularly from a historical and sociology of knowledge standpoint, would illuminate not only this particular genre of studies but rural sociology as a discipline.

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Social Connectedness in Marginal Rural China: The Case of Farmer Innovation Circles in Zhidan, North Shaanxi

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Introduction

Despite remarkable recent achievements, rural poverty elimination still presents significant challenges in China (Khan, 1998; Piazza and Liang, 1998; Yao, 2000; World Bank, 2001). Poverty is particularly endemic in marginal areas characterized by problems of both poor asset stock (natural, physical and human capital) and the scarcity of capital inflows (e.g. financial, technology, information and talent) (Shen et al, 1992; Zhu and Jiang, 1996; Jalan and Ravallion, 1997; Rahman and Riskin, 1998; Rozelle et al, 1998; Yang, 2003). If there is to be a breakthrough for rural development in these marginal areas, then agricultural innovation is widely viewed as a necessary condition (CAS, 1991; Yao et al, 1996; Fan and Pardey, 1997; Yonggong, 1998; Zhuge and Tisdell, 1999). Yet technological innovation is constrained by the difficulties that formal agricultural extension finds in reaching remote and inaccessible areas (Delmen, 1991; Shi, 2001; Wu, 2003). This lack of communication and interaction between farmers and agricultural professionals constrains the fit between supply of new technologies and the pressing needs of the rural poor (Liu, 2000).

Hitherto, most attention has been paid to improvement of development assistance and agricultural extension, rather than assessing the development potential of marginal communities themselves. These are dynamic and diverse, with great potential for innovation in both technologies and self-organization (Pretty, 2002; Uphoff, 2002). This paper explores the implications of farmer innovation and local self-organization for government and agricultural professionals. The focus is

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on rural communities of north Shaanxi of China and the phenomenon of 'farmer innovation circles' (FIC). These are informal social systems used by the rural poor for their own technology development and cooperation. We explain the theoretical background and analytical framework, then summarize the features of Zhidan County and the methodology used. We then analyse the distribution of household innovative capacity, and then link this to wider innovation circles and household incomes. We then show how innovative capacity is accumulated in a case study, and conclude with reflections on the development and policy implications.

Social Connectedness and Farmer Innovation Circles: A Conceptual Framework

With constraints on local asset stock and access to external resources (finance, technology, information), rural communities in marginal areas face significant challenges to secure and sustain their livelihoods. It is now widely accepted that livelihoods derive goods and services from five assets (comprising natural, social, human, physical and financial capital), and such livelihoods can be said to be sustainable when they can cope with and recover from stresses and shocks and maintain or enhance assets and capabilities, whilst not undermining the natural resource base (Carney, 1998). In marginal areas, the shortage of other formal assets means that a key resource available for the poor is social capital – their capacity to work together to cope with common challenges (Coleman, 1988; Putnam et al, 1993; Flora, 1998; Krishna, 2002; Uphoff, 2002). Social capital can be identified as having four core aspects: (i) relations of trust, (ii) reciprocity and exchanges, (iii) common rules, norms and sanctions, and (iv) connectedness in networks and groups (Pretty and Ward, 2001).

The idea of social connectedness suggests a means to assess social capital and its effects on rural livelihoods (Chang and Feuchtwang, 1996; Putnam, 2001; Krishna, 2002). Social capital can be enhanced with increasing social connectedness, such as a growing frequency of communication and mutual support between households, or created, such as by the establishment of new cooperatives or groups. It may also be diminished through the expansion of individualism and conflict. Equally, it cannot be assumed that social capital is always good for all members of communities (Knight, 1992; Fine, 1998; Woolcock, 1998). An important, though often neglected, aspect of social capital is the way it relates to innovation. In many contexts, there is a need to focus on the types of social capital that enhance capacity to solve problems rather than just focus on overall quantitative increases or decreases in social capital (Flora and Flora, 1993; Pretty, 2002). In the face of high uncertainty, the capacity of people in marginal areas to innovate and adapt technologies and practices becomes vital for rural development. In vulnerable and marginal communities, this need for innovation is even stronger (Chambers et al, 1989). An important development question centres on whether forms of social capital can be accumulated to enhance such innovation (Cernea, 1987; Pretty, 1995; Röling and Wagemakers, 1997; Pretty, 2002; Uphoff, 2002).

The importance of social capital for the rural poor in marginal areas can be assessed by studying the relationship between social connectedness and household innovative capacity. The lack of external resources and support means that the poor have to learn and diffuse new technologies by themselves. Here we use the term 'farmer innovation circle' (FIC) to refer to the informal networks, groups or mechanisms used by farmers for their own technology development and sharing. We therefore pose three questions. Is there any evidence to indicate the existence and successful functioning of FICs? If so, how effective are they in marginal areas in increasing incomes for the rural poor? And finally, by what patterns and mechanisms do the rural poor establish, maintain and develop FICs to enhance their innovative capacity?

Zhidan County: Background and survey methodology

A rural survey was conducted in north Shaanxi in the summer of 1997. Located at the heart of the Loess Plateau, Zhidan is one the most ecologically fragile counties of north China. Of its 3781km^2 land, three-quarters are affected by serious soil erosion. In addition, Zhidan has the status of a 'nationally-assigned poor county', which means it shares many common features with other 'poor counties' in rural China. Table 15.1 highlights the several features of Zhidan's rural economy.

Zhidan is an 'agricultural county' where some 90 per cent of its population are dependent upon agricultural economy, which is similar to most of Shaanxi's 102 counties. Although Zhidan was one of 50 'nationally-assigned poor counties' within Shaanxi province, its rural income per capita and rural incidence are close to the provincial average. Regarding sustainable rural livelihoods, Zhidan has an advantage in grain production where the annual grain production per capita was 386kg/person, 54kg higher than the provincial average. But the average production per area of farmland in Zhidan was about one-fifth of the provincial average,

Table 15.1 *Secondary data on study area*

Indicators	*Zhidan County*	*Shaanxi Province*
Rural share of the total population (%)	88	86
Rural net income per capita (yuan/person)	816	850
Rural poverty incidence (% of households)	20	18.5
Annual grain production (kg/person)	386	332
Annual grain production (kg/mu)	23	93
Cultivation of steep slopes (% of farmland over 25^o to total farmland)	29	16
Inorganic fertilizer use (kg/person)	222	446
Power of farming machine (kw/person)	1.7	3.4

Source: National Bureau of Statistics (2000), Shaanxi's Agricultural Department (1996) Shaanxi's Agricultural Regionalization Office (1989). Data refer to various years in the 1990s mainly because of poor quality farmland, cultivation on steep slopes and the low use of external production factors (e.g. fertilizers, farm machinery).

Zhidan County can be divided into four main regions. Generally, the north is high in elevation (1300–1741m), with extensive gullies and poor vegetation. In the south, altitude (1093–1680m) and population density are lower, with dense woodland cover. Between them, middle Zhidan is relatively gentle in topography, with dense population and good agricultural facilities. The eastern part is the county's political and economic centre with good transport, an emerging local oil industry and expanding urban markets. By contrast, the western part shares similar agricultural resource conditions but has few non-farm economic opportunities. One township in each of the north, west and east regions was selected for investigation. The south was not sampled for two reasons – it is part of a national forest zone in the Loess Plateau, with a quite different landscape from the rest of Zhidan, and a state-owned company manages forestry and grazing resources.

Table 15.2 gives the secondary data for the three selected townships. Zhidan is heterogeneous in terms of resource endowment and development opportunities. Among three sample townships, for instance, the length of road in Zhonghe is longer than the sum of other two townships, indicating an uneven distribution of rural infrastructure. Whilst the average value of Zhidan's rural net income was close to the provincial average, Zhifang, the poorest township of Zhidan, has only two-thirds of the county's average. It is not surprising that according to the Zhidan Poverty Reduction Office, the majority of the rural poor in Zhidan are concentrated in its north and west zones, and in particular these remote and high-mountain villages are characterized by long distances to main roads and markets, poor vehicle access and a high rate of inattendance at school. Unlike other 'poor areas' in Shaanxi, grain shortages are not significant for Zhidan at the aggregate level.

The field survey consisted of three elements: participatory observation and village comparison, household questionnaire survey, and mini case studies. All administrative villages in each sampled township were divided into three groups according to rural net income in the previous year, and one of each group was selected as a sample administrative village. All sub-villages (or natural village or

Table 15.2 *Comparison of selected townships in Zhidan County (1995)*

Indicator/Township	*Zhouhe*	*Zhifang*	*Jindin*	*County*
Location	East	North	West	–
% of county's land	6.3	7.0	10.4	100
Road length (km)	135	39	89	nd
No. households	1736	1277	2386	20,474
No. population	8455	6656	12,518	100,698
Net income (yuan/person)	1300	480	760	804
Grain production (kg/person)	465	311	395	393

Sources: Zhidan Planning and Statistical Office (1996), Zhidan Agricultural Survey Office 'villager group' in official terms, village hereafter) were included in the survey. In order to overcome standard geographic biases, a 'barefoot' strategy (eating and living with local people, walking on foot instead of taking vehicles) was adopted by the survey team, which comprised the first author, two local assistants, and 1–2 farmers. A standard format, 'village information sheet' was employed for the purposes of participatory observation and village comparison, which covers the baseline information of each village, including: geographical location and topographic features, population and demographic information, distribution and utilization of land resources, village history and social structure. During the period of on-foot movement from one village to another, the survey team cross-checked official statistical data, and developed hypotheses and questions for later village discussions. On arrival in the village, a group meeting was held to complete the 'village information sheet', to examine and improve research hypotheses, and to explore key issues raised by local people. In total, 50 villages within nine administrative villages were visited and village information sheets completed for each.

Whilst village surveys were concentrated on the environment and resource management issues, the household questionnaire survey provided a means to collect the information on rural livelihood systems, to measure the inputs and outputs of household production systems, and also to quantify the scale and structure of social networks. Besides the detailed information on household revenues and expenditure, special attention in the household questionnaire surveys was placed on understanding links between kinship, relatives and village residents, the closeness of households and the relations of trust and the capacity for people to ask for help without worrying about refusal. It also focused on production and technology issues, and who households usually consult – with a focus on channels or sources for households to learn about technology information and who influences family decisions on adoption. Following a standard process, one in five village households was selected by a systematic random method.

Mini case studies were also used during or after the period of village surveys to develop a more detailed picture of farmer innovation and organization practices. As a result, a total of ten case studies were analysed, covering a range of themes from the adoption of greenhouses for vegetables, the invention of rainfall collecting system, reform in rural property system to links with agricultural extension systems.

Local Conditions and Household Innovative Capacity

All 50 sample villages have been allocated to one of three categories (valley, middle and remote) according to a variety of geographic and resource endowment characteristics (Table 15.3). This shows that regional divisions based upon administrative hierarchy underestimates the complexity of rural environments because the differences between the valley and remote villages is large. Some administrative villages contain all three types of village (valley, middle and remote),

Table 15.3 *Division of sample villages and resource endowments*

Village category	*Valley*	*Middle*	*Remote*
Average altitude (m)	1260	1370	1500
Farmland per household (mu)	5mu, irrigated	3mu, terraces	2mu, terraces
Road access	main road	simple vehicle road	No road likely
Electricity power connection	Yes	Ready soon	None
Drinking water source	Within village	Nearby village	Distance (>1.5km)
Distance to main road (km)	0	4	8
Distance to local market (km)	5	8	18
Village size (household)	29	20	14
Net income per capita (yuan/person)	1318	740	578

Source: Data are derived from survey of 50 villages (5 valley, 18 middle, 27 remote)

whilst others have only middle and remote villages. Thus comparisons at township or administrative village levels may not accurately reflect the particular issues facing these remote villages.

Our survey showed that valley villages had more opportunities to access inward investment (e.g. the re-establishment of irrigation systems in recent years) than remote and middle villages. Households in valley villages were predominated by cash crops and non-farming activities, whilst the main sources of household income in the remote villages were from the traditional grains and small livestock. As the middle villages are closer to remote villages in terms of resource conditions and development patterns, we combined their data to compare with the distinctly different context of valley villages.

The questionnaire survey was used to measure three aspects of household innovative capacity in terms of production technologies: the use of production inputs, the structure of household production revenues and level of household net income per capita. By contrast to traditional farming system (no or low production inputs, heavily dependency on grain and sheep, and low economic returns), these criteria provide a set of the objective indicators to recognize the different capacity of household technology learning and adoption. Giving a range of scores from 1 (low), 2 (medium) to 3 (high) to assess household use of production inputs and structure (which refers to the share of new products in household cash revenues) respectively, each household was allocated a total score for innovative capacity. As a result, Table 15.4 shows a range of the total scores in the left column from the minimum of 2 to a maximum of 6. Combining total scores vertically with net income levels horizontally, all sample households can be divided into three groups from bottom left to top right, resulting in three levels of household innovation capacity (HIC). Adopting an assessment panel shown in Table 15.4, all households were graded into three groups for HIC: high, medium and low.

Table 15.4 *Division of household innovative capacity by score and income (number of households)*

Total HIC score	*Income (yuan per person)*				*Households in each HIC class*
	<300	*300–699*	*700–999*	*>=1000*	
6	0	*3*	**9**	**15**	**27**
5	0	*9*	*3*	**4**	**16**
4	**10**	*11*	*9*	**13**	**43**
3	**8**	**17**	*3*	*4*	**32**
2	**10**	**19**	*1*	*1*	**31**

Households with high innovative capacity are those with the capacity to seek, adopt or develop a new production technology or practice by themselves. By contrast, those with low innovative capacity are unlikely to adopt innovations unless major barriers (e.g. information, credit or selling risk) are removed. Not surprisingly, over three-quarters of households in valley villages fell into the category of high HIC, whilst 60 per cent of those in remote villages were in the low category. Some 30 per cent of households in the middle villages were high and 42 per cent low in the HIC assessment.

To examine the features of the HIC and the impacts of the local resource environments, all households in middle and remote villages were compared based upon the division of their HIC. Samples in valley villages are taken out from the comparison in order to reduce the impacts from predominant resource factors (access to main roads, irrigated land, electricity and TV connection). Table 15.5 highlights

Table 15.5 *Features of the levels of HIC and relevant factors in marginal areas of Zhidan*

Category	*Low HIC*	*Medium HIC*	*High HIC*
No. households	64	39	24
Net income (yuan/person)	336	762	1357
Product inputs (yuan/person)	104	180	193
Proportion of income from new cash crops and non-farm income (%)	18	40	69
Distance to central village (km)	2.0	2.8	1.9
Distance to main road (km)	5.6	7.5	3.9
Education: <=1 ys (%)	42.2	35.9	29.2
2–5 ys (%)	39.1	33.3	20.8
>=6 ys (%)	18.8	30.8	50.0

Note: New cash crops include hybrid seed plantation, greenhouse for vegetables, fruit and herb plantation, and non-farming is derived from wool, blacksmith, bricklayer, tiler, carpenter and various other labour services.

major features and relevant factors influencing the distribution of the HIC in the marginal areas of Zhidan, with households with high HIC having 78 per cent higher income than medium HIC, and 400 per cent higher than low HIC households. In addition, it shows the significant difference of both production input and output structures amongst various groups.

Household Innovation Circles

Despite great variation, we found that all rural households have their own communication networks which comprised village kinship (male line, usually in the same village or distribution in nearby villages), close relatives (mainly extended family in-laws in outside villages), and friends (including close neighbours within villages and friends beyond) (Wu et al, 2002). The components, scale and utility of one household communication network are as follows.

In a remote mountain village (20km from Zhidan county town), with 18 household residents and three extended families, Mr Zhang (37 years old) is head of a household of five persons (his wife, two daughters and one son). He reported that he had four kin in his village including one parent (separated from his household), two married brothers, and his father's brother's son (married as well), which are important for his family in terms of security, emergency aid (borrowing grain and cash) and farming experience (his father). Of the other 13 non-family residents in his village, five were identified by him as close neighbours because they often joined together for labour exchange. In addition, he had six friends living in neighbouring villages, whom he met frequently either on his hill plots or in the township market, in order to discuss a range of issues concerned with production, technology, economy and other topics. In addition, his family benefits from frequent interaction (at least 2–3 times per year) with ten of his 'close relatives' (e.g. parents-in-law, two brothers-in-law, three married sisters) in terms of not only a wide source of outside information but also a potential pool of labour, farming tools and sometimes cash. Beside these close relatives, he had three kin living in the county town, his father's brother and his two sons, one of whom is close to him. As a result, a total of 28 households are members of his household communication network for the purposes of information and technology exchange, together with social support and security.

There were several findings on the relationship between household communication networks (HCN) and their innovation capacity. First, there was no difference between valley, middle and remote villages in terms of the total size of the HCN. This seems to suggest that the HCN itself is not merely owned by marginal people but shared by all rural residents. Second, the number of household kin is not related to the variation of the HIC, which is supported by local opinion that kinship at present is little help for household production and technology learning, but may be useful for livelihood security, particularly in borrowing grain or cash to cope with unexpected events. Finally, in addition to kin living in the same or nearby villages, distant close relatives deliberately also facilitate household technology learning and innovation. The role of these close relatives for household innovation is shown by the case of the wide-furrow plough (*Da Long Gou*)

This is a new sowing technology introduced by the government in the early 1990s for the purpose of increasing grain production in mountainous areas. Compared with local traditional sowing methods, the plough can increase grain productivity per unit of land, but requires specific conditions, including good quality land (on terraces, plains or gently sloping land), access to labour and draft animals, and intensive use of external inputs (fertilizers and plastic sheets). Although the government has employed many measures, including administrative intervention and financial subsidies (low-interest loans) to encourage adoption, we found that by 1997 only 62 per cent of households had adopted the new technology, and that the adoption rate in the low mountain villages was higher (73 per cent) than in the high mountains (57 per cent). The difference in adoption rate can be explained by several factors, particularly access to the innovation because of the typically limited provision of demonstration plots and extension staff in the mountainous villages. HCNs appear to have played a positive role in technology adoption, as evidenced by the following statement from a housewife in a remote village: 'The wide furrow programme has interested this village for many years, but we were uncertain of the technical details and cost–benefits until a relative of mine from a low mountain area came to my plots to put on a demonstration last year. Seeing the good results, all the residents in the village have adopted it this spring.' Farmers do not like to adopt new technologies without the opportunity to subject it to close and personal scrutiny, and so the views of close relatives were critical in encouraging her family and neighbours to adopt.

Compared with traditional kinship and relatives, neighbourhood mutual aid and cooperation appear more important for household technology learning and adoption. One of the important factors driving villagers' interactions is that most households suffer from labour shortages in the busy farming seasons (e.g. at sowing). On average, each household had 2.4 workers and 60mu (4ha) farmland, so it is not easy for them to complete sowing alone in a short period (typically 1–2 weeks, and possibly less given that frequent spring droughts often reduce the window of opportunity to only a few days). To overcome these problems, a common strategy is for several households to exchange labour for collaborative sowing. However, not all households in a village are prepared to exchange their labour (or farm tools) with others. While many households benefit from neighbourly mutual aid, others can find it difficult to complete sowing without their relatives' help.

According to the survey, only 20 per cent of households had sowing machinery whilst 25 per cent either did not have draught cattle or experienced a cattle shortage. Neighbourly mutual aid was thus an important precondition for adopting the new level plough, first extended in Zhidan in the 1980s to replace traditional methods. One of the common strategies popularized in the Loess Plateau is that several neighbours cooperate to complete sowing based upon the principle of 'equal exchange' of labour or between labour and cattle or seeding machines.

Table 15.6 *Average size of household communication network by innovative capacity*

HIC level	*No. of HCN*	*Friendly villagers*	*Close relatives*
Low	25	7	11
Medium	31	10	13
High	34	13	14
Significance	0.016	0.003	0.268

Note: This table is derived from a one-way ANOVA analysis on the household questionnaire survey, with households in valley villages again excluded ($N = 127$).

However, not all households are able to exchange their labour or tools with neighbours. For those with tense relations with neighbours, it was difficult for them to join in cooperative arrangements. Instead, they had to depend on assistance from kin or relatives.

Household communication networks also help to spread ideas and technologies. Apple plantations as a new technology, for example, often spread in those villages where more than two households join together for tree management, mainly to avoid sheep damage and theft of fruit. Of those villages with apple orchards, we found that 36 per cent had two orchards (i.e. two households collaborating) in each village, whilst 41 per cent had more than three households involved.

Table 15.6 shows that there is a relationship between the connectivity of households and their innovation capacity. While the scale and style of rural social communication varies household by household, the results from the analysis of variance indicate that there is a significant relation between household innovative capacity (HIC level in the first column) and the average size of household communication network (second column). As we have indicated, household communication networks comprise many components (kin, close relatives and friendly villagers). Table 15.6 indicates a correlation between the number of friendly villagers and household innovative capacity: the larger the number of the friendly villagers (the third column), the higher the household's HIC. The contribution from close relatives (the right column) to the HIC is weaker. Kinship, another component of the household communication network, is not shown as there was no statistical correlation with household innovative capacity.

These findings are supported by a popular local statement: 'Able men are those who have more social links' (local is called *menlu*). Due to the constraints arising from remoteness and weak formal extension networks, more social connectedness means more opportunities to access scarce resources such as information, technology, financial capital and consultation. The HCNs, however, remain loose networks of social connectedness because many are held together by individual households, and there may not be any linkages between different HCNs.

In addition to these loose HCNs that are shared by all rural households at various scales, a variety of focused technology learning groups also appear important in these marginal areas. Compared with the HCN, those groups are characterized by closer social connectedness, because participants have a clear innovation objective, and tend to share production tools and managerial responsibilities. Many phenomena are addressed by these groups, including collaborative buying, group orchards, tobacco and herb plantations, and joint investment for machinery. Such focused group learning is often driven by a central household who takes charge of innovation initiatives, organization and harmony.

One example is Wang's vegetable production group, which now accounts for about half of the village's vegetable production for the county market. This is one of three informal groups within the village. They are the most successful because Mr Wang was a pioneer in adopting and improving greenhouse techniques for vegetable production, as well as promoting a volunteer organization for innovation diffusion. As a result, his greenhouse has become both a free 'training school' and an 'experimental plot' for new technology, which attracted a large number of his neighbours and outside farmers. During the long and very cold winters, more than 20 people regularly assemble in Mr Wang's house for discussions and celebratory meals. As a result, a stable cooperative relationship has emerged among participants, which Mr. Wang oversees as 'leader', while his greenhouse is referred to as '*xiao tian di*', meaning a small but very convenient place like a warm family.

Not limited to greenhouse or vegetable production, innovation groups are very common for cash cropping which relies on frequent communication, intensive labour and management inputs. However, it would be wrong to assume that all groups are similar to Wang's group. Some innovation groups are dominated by kinship, in which non-family neighbours are absorbed but are distant from group decision making. The next case indicates an important fact: technology diffusion in the marginal areas is not always determined by the factor of 'physical distance' but sometimes by 'social distance', in which social connectedness again plays a key role.

Two remote villages are close to each other (only 3km apart). Village A has a strong advantage in apple orchards, as all residents have established their own orchard to share knowledge from an expert living in the same village. By contrast, the neighbouring village B had just begun to develop orchards (three households only). Surprisingly, the technical sources in village B were not from nearby village A, but from a distant village C in another township (10km away). This inefficient technology transfer was mainly because of two factors: (i) the scale demand for services from villagers – seldom would a graft technician go to a village if the scale of the orchard was too small (less than 5mu); (ii) the price of the graft service – the normal price of 6 *yuan* per tree was too expensive for most of the farmers in Village B. Village B might not have adopted apples had not a farmer's relative (brother-in-law) resident in village C offered a cheap service (only 2 *yuan* per tree).

Several conclusions can be drawn from the field findings. First, the physical environment influences but is not the sole determinant of household innovation capacity. Beyond the conventional extension system, there are many types of farmer innovation circles existing in marginal areas, through which the poor join together to learn, diffuse and share new technologies. However, the role of such social connectedness should not be idealized nor overstated. Second, social connectedness is not abstract but has roots in the daily life of farmers. Despite great variations in terms of 'organizational' formats, it can be identified and measured through farmer communication networks comprising kinship and neighbourhoods within villages, and close relatives and friendship outside of village. It is these networks that provide a fundamental rationale for farmer innovation and self-organization in marginal areas of Zhidan county. The larger the network, the greater the innovation.

The Case Study of Taoliwa – an 'Evergreen' Village

Farmer innovation circles (FIC) as a form of social capital span a spectrum from loose and general-purposive social communication to more focused and specialized groups. By accumulating and enhancing social connectedness, there is a possibility of 'organizational innovation' leading to a scaling-up of the innovative group or emergence of new higher-level organizations. Deforestation is a serious challenge for the Loess Plateau. Amongst the bare mountains, there are, however, some 'green islands' of villages surrounded by meadows and trees. In these villages, the high income levels and positive mental attitudes are evident. In order to address why these 'green islands' emerge, we used case studies to provide further insights into how the social connectedness can be accumulated and upgraded, leading to further enhancement of household innovative capacity. This section focuses on one of the ten case studies conducted during the field survey.

Taoliwa (meaning a convenient place producing pear and peach), is a remote mountainous village on the border of north-west Zhidan. Of 17 households, all belong to descendants (11–13th generation) of the eighth Liu's generation, since their ancestor moved into the village from a neighbouring province some 400 years ago. Despite many periods of social upheaval in the 20th century, the Liu's clan still kept a comprehensive record of their clan history. Among 69 close kin and relatives listed in their clan book, the majority are distant urban residents, some of whom live in the cities of Beijing, Xian and Lanzhou. They are proud that a famous Kuomintang general in the 1920–1930s, the tenth generation of the Liu clan, was born and buried in this village.

Similar to elsewhere in Zhidan, some two-thirds of the village land had been covered by forest, until the middle of the 1930s, when large-scale deforestation began. Deforestation was further exacerbated during the period of collectivization, the 'Great Leap Forward' in the late 1950s, and the 'cultural revolution' (1966–1976) in particular, when the village was identified as an 'object of dictatorship' due to General Liu's Kuomintang history. In addition, the continuous growth of population and cultivation was an important factor contributing to deforestation. In particular, the rural reforms of the early 1980s provided a strong stimulus for over-cultivation, when the area of cultivated land reached a peak of 1100mu in 1984, nearly 40 per cent more than that in 1980. By the middle of the 1980s, while the village food needs were met, forest resources in the Taoliwa had been exhausted and the shortage of firewood became a critical constraint.

To overcome this problem, a collaborative afforestation project was initiated. All residents shared a common idea: if the village were to survive and develop, all households should share responsibility for tree plantation and management. Without changing the nature of the household responsibility system, they reached an agreement on local rules and sanctions, which set out that there would be collective planning of tree plantations with all households participating in decision making; each household would be responsible for its own tree seed selection, plantation and management; responsibility for woodland protection would be shared by all residents; a security coordinator would be appointed to harmonize woodland management between households; and strict punishments would be enacted if livestock entered the woodland.

Close unity and cooperation among villagers is vital if young trees are to be protected from attack by sheep and goats. Indeed, if the village's own sheep could not be prevented from entering the afforested land, it soon follows that flocks of sheep from neighbouring villages would also enter. Due to strict management regulations, many sheep owners in the village have indeed been fined, which has increased the deterrent on outside free-riders. Successful management, in turn, encouraged villagers to make continuous efforts in afforestation year by year. By 1997, all four hills of the village were covered by trees, and the area of forest has expanded to 1000mu or nearly 60mu per household, more than 10 times the per capita county average. The benefits of tree planting go beyond firewood, as they have also become an important source of household income through construction timber and fruit trees.

Successful afforestation has provoked agricultural change too, including a transformation of more than 200mu of over-cultivated farmland to firewood land and fruit orchards; a 400mu planted grassland to secure fodder supply; and development planning of commercial pig, oxen and fish breeding for the purposes of both cash generation and organic manure supply. Indeed, the demand for agricultural innovation was so strong that the village representatives have visited the county town to seek new technologies (e.g. level plough and wide furrow, new seeds of grain crops and trees), which at first surprised government officers and professionals because this so seldom occurs. Cooperation has also extended to infrastructure, including the construction of a 4km local road connecting to the main road, access to the outside electricity network, and a central system of water supply for domestic use and animal breeding.

At first sight, it is surprising that so many achievements have been made by farmers themselves, in contrast with the typically short-life or expensive 'experimental', 'demonstration' and 'model' projects funded by governments in the poor areas. The success in Taoliwa would be difficult to understand without uncovering the organizational process. The idea of cooperative afforestation and sustainable development in Taoliwa was originated by an urban kin, the son of General Liu. As an engineer in a state oil company (about 200km away from the village), Mr Liu was persecuted and forced to return to the village during the period of the 'cultural revolution' (1966–1976), owing to his father's history. It provided a unique opportunity for him to gain an in-depth understanding of rural poverty and development. Although his political reputation and position recovered in 1979, he kept close contact with his village, visiting every year. He came to stress the following opinions to his rural kin and neighbours:

> The village's environmental and development issues [e.g. deforestation, inaccessibility to a road] will not be solved if we wait for the government. Rather than be dependent on external assistance, it would be better if all villagers were united and cooperated to open a 'green account' for afforestation and pasture plantation. The significance of cooperative afforestation is not only to provide a sustainable treasure for our descendants, but, if it succeeds, it will offer a novel path for our neighbouring villages and even Zhidan county as a whole – that is, close unity and cooperation rather than the current individualist development will lead to a sustainable future.

Gradually, this idea was shared and supported by all villagers, and the first plan for a firewood plantation emerged at a village meeting chaired by him. Based upon the success of afforestation, a long-term strategy of agricultural innovation and village development was discussed and approved by all villagers in the early 1990s, which then became the blueprint for village development and cooperation. Besides designing the plan, his particular contribution was the establishment and development of a cooperative mechanism, by which all issues related to inter-household relationships and village development are discussed and negotiated in public meetings among all households. Following Mr Liu's idea, a leading core group of three middle-aged farmers has taken charge of organizing, coordinating and harmonizing all households to implement the blueprint.

To improve rural infrastructure, Mr Liu returned to the village to design and initiate a 4km length of vehicle-suitable road, just after he retired in 1993. Without exogenous funding, he contributed 3000 *yuan* from his personal savings and wrote letters to all urban kin nationwide for further donations. Though he died in the period of road construction that winter, Mr Liu's death did not halt the progress of proposed projects, but encouraged villagers to strengthen their unity and cooperation. Learning from Mr. Liu, more urban kin (including his son) have participated in their home village reconstruction, and 'building an evergreen home village' (villagers' phrase) has become a common objective shared by both villagers and their urban kin.

Despite its uniqueness, this case does contain some common elements contributing to the establishment, maintenance and development of community innovations. The historic heritage of the Liu's clan was an advantage, as descendants in the village could reorganize themselves to address ecological degradation and firewood shortages. However, without the spark provided by Mr Liu, these ecological pressures might not have led to innovative organization. An 'opinion leader', or 'innovative core', is thus an important element to drive such collaborative action. Under the household responsibility system in rural China, cooperative consciousness as a core of social capital is particularly important, and provided a sound basis for Taoliwa's people to break through the constraints of narrow individual interests, and to form and maintain a new development dynamic instead. Without returning to the abandoned and formal 'collective system', Taoliwa has developed a new form of collective action. Finally, all these elements were integrated into an 'innovation network' comprising village residents, farmers in nearby villages and urban relatives, leading to an enhancement of village innovation capacity, with a spreading impact on nearby villages.

There are also important generalizable lessons from this specific case of social connectedness in Taoliwa. First, development in the village did not stop after Mr Liu died, which indicates that a more distributed network is driving sustainable development rather than just one person. Second, Taoliwa's experience was not limited within the village but had spread to a number of neighbouring villages. Reflecting the popularity of Taoliwa's experience, the head of Taoliwa was recommended and elected by the residents as director of the administrative village commission. Finally, Taoliwa's experience seems to suggests that as part of traditional culture, the natural links between urban residents and their rural relatives offer another route for rural economic development and technological innovation.

Enhancing Social Connectedness

Compared with other regions, social capital is more important to the marginal areas of China where unfavourable geographic and resource environments constrain the inflows of external capital and knowledge. The importance of social connectedness for the sustainable rural livelihoods in the marginal areas of China has been illustrated through the phenomenon of farmer innovation circles (FIC). Organizational patterns at various levels from household communication networks, inter-household technology learning groups and inter-village innovative links have a positive effect on agricultural and natural resource innovation, which in turn improves rural incomes.

However, it would be romantic to say that enhancing social connectedness by itself necessarily leads to sustainable rural livelihoods as social capital is merely one of many elements affecting local livelihoods. Nor is it true that the FIC alone can meet the needs of farmers entirely without external capital and assistance. Whilst the benefits of external intervention should not be underestimated, top-down development might be neither successful nor sustainable unless the innovative potential and intrinsic dynamics among the poor are fully recognized and developed. If there is to be sustainable development in the marginal areas of China, then there will clearly need to be closer communication and interaction between agricultural professionals and rural communities.

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Part IV

Ecological Restoration and Design

16

Ecological Design and Education

David W. Orr

Ask the animals, and they will teach you; the birds of the air, and they will tell you; ask the plants of the earth, and they will teach you; and the fish of the sea will declare to you.

Job: 7–9

When you build a thing you cannot merely build that thing in isolation, but must also repair the world around it, and within it so that the larger world at that one place becomes more coherent and more whole; and the thing which you make takes its place in the web of nature as you make it.

Christopher Alexander

Background

Imagine living in a random world without order in which no rules applied, and effects followed no discernible pattern of cause. Such a world would be alien to intelligence, morality and foresight, governed instead by caprice and whimsy, which is to say that it would be a kind of Hell. Design presumes, on the contrary, that matter is ordered and that order matters. But to the questions of exactly what is ordered and how there is no one answer. The more we know, the more mysterious the world appears to be. Beyond the regularities of changing seasons, birth and death, the world that we experience is often chaotic and violent governed as much by fate as by foresight. But even that awareness fuels the effort to discover larger patterns, mastery of which will permit us to establish safe haven or, for some, heaven on earth. For the builders of megalithic monuments like Stonehenge, the clues to order lay in the observed regularities of the night sky and the movements of the sun, moon, and stars. The Greeks, believers in the possibility of reason, discovered geometrical proportions and mathematical harmony in the world. Some believed that cultivation of reason might lead to societies in which reasonable men might collaborate to manage public affairs democratically, yet another level of harmony. For the ancient Jews, the basis of order was otherworldly, a moral order evident in the Laws God delivered to Moses. For the builders of the great cathedrals, that belief was extended into architectural form blending Greek geometry with Judeo-Christian theology in service to the idea that inspired humans could design so artfully as to create sacred spaces that were a portion of heaven on earth.

The fourth great design revolution, built on modern science, presumed a more remote God who had once created a clockwork universe and had the good sense thereafter not to meddle with it. Isaac Newton deciphered the scientific laws God had presumably used and rendered these into the metaphor of a cosmic machine. Adam Smith took that metaphor to describe our tendency to truck and barter as the working out of an invisible hand administering the laws of supply and demand in a mechanistic world. In the fourth revolution, the economy of Adam Smith is the ultimate machine, godlike in its ability to sift order from the chaos of individual self-interest. We continue to live in that faith, now extended to a further abstraction called the global economy.

Each of the design revolutions in some degree persists like geologic layers. Unlike the scientific revolutions described by Thomas Kuhn in which one paradigm overthrows another, less adequate, our sense of order is a kind of lamination in which earlier thinking persists whether in science, social structures, language or even commonplace superstitions. Each transformation in our understanding of how to make the human presence on Earth surrendered in due course to time, human frailty, and their particular flaws, but did not thereby disappear. The megalithic belief in a larger order evident in the rising and setting of the sun, lunar cycles, and movements of the stars survives in the belief that patterns of ecology represent a larger ordering applicable to human systems. So too, the belief that human reason might yet bring order from unreason and caprice. The Greek experiment in rationality survived and flourished in the Christian era as part of what Arthur O. Lovejoy once described as 'the great chain of being' (1936/1974). If humans had the capacity of reason, might they not also discern the very mind of God. The neo-platonism of the medieval world, in Lovejoy's words, 'rested at bottom upon a faith … that the universe is a rational order … a coherent, luminous, intellectually secure and dependable world, in which the mind of man could go about its business of seeking an understanding of things in full confidence' (Lovejoy, 1936, pp327–328). Faith in a rational order and the powers of rationality survives into our time, magnified by the Enlightenment of the 18th century into the creed of inevitable progress. The faith of the medieval churchmen survives not just in the millennarian assumptions of nearly every ideological movement, but in the belief that what we made on Earth ought to reflect higher obligations than those of self-interest. That, too, is an echo of the ancient belief in a divine order that would lead to a final triumph of right.

The increasingly homogeneous industrial civilization that now stretches around the Earth is the signature accomplishment of the fourth revolution, but its future is troubled for reasons that any moderately well-informed high school student could recite. Its prospects are clouded, first, because it is inflicting a rising level of ecological damage evident as impaired ecological functions, the loss of biological diversity, mutilated ecosystems, spreading blight, pollution and climate change. For the scientists who study Earth processes and ecology the facts are well-known. Due to the loss of habitat and pollution, the number of species on Earth will decline by a quarter to one-third in this century. The carbon content of the atmosphere has increased by more than a third from its pre-industrial level of 280ppm and is rising at a rate now of over 2ppm per year, a harbinger of worse to come. The human population has increased six-fold in the last two centuries and will grow to 8 or 9 billion. The number of large predatory fish in the oceans has decreased by 90 per cent. Worldwide soil loss is estimated to be 20–25 billion tonnes per year. Forests, roughly the size of Scotland, are disappearing each year. Within a few years or maybe in a decade or two, we will reach the peak of the era of cheap oil where supply and demand diverge and start down the backside of the curve. That transition could be the start of an era of bitter geopolitical conflicts. Harvard biologist, Edward O. Wilson refers to the decades ahead as a 'bottleneck', an uncertain passage through constraints caused by the loss of species, climatic change and population growth (Wilson, 2002). The scientific evidence documenting the decline of the vital signs of the Earth is overwhelming, so too the burden of pondering such complicated and dire things which may help to explain the growing popularity of escapism, religious zealotry, hyper-consumption and other modes of denial.

The industrial experiment is failing, too, because of growing inequities and violence. In spite of nearly a century of economic growth, a majority of people on Earth experience life close to the bone. Over 1 billion people live at the edge of starvation in absolute poverty. Their daily reality is hunger, insecurity and hopelessness. At the other end of the spectrum another billion live in affluence and suffer the consequences of having too much. Powered by cheap fossil energy, their world is one of traffic jams, suburban malls, satiation, fashion, fad diets, addiction, boredom, excitement and commercial entertainment. In spite of high rates of economic growth, the trend is toward greater and greater inequity that is leading to a world dominated by a handful of corporations and a few thousand super wealthy. These two worlds appear to be diverging, but in fact their destinies are colliding. Security, once a function of distance and military might, has been radically changed by terrorism and the diffusion of heinous weaponry. National borders no longer provide safety. The powerful and wealthy are vulnerable now precisely because their power and wealth makes them targets for terrorists and malcontents. And ethics, once a matter of individual behaviour, now includes the conduct of whole societies and entire generations whose choices about energy and resource use cast long shadows across the planet and into the far future.

The inability to solve ecological and social problems points to deeper flaws. Like the proverbial fish unaware of the water in which it swims, we, too, have difficulty perceiving fatal flaws in our ideas, paradigms and behaviour that we take for granted until it is too late. In Jared Diamond's words 'human societies and smaller groups may make disastrous decisions for a whole sequence of reasons: failure to anticipate a problem, failure to perceive it once it has arisen, failure to attempt to solve it after it has been perceived, and failure to succeed in attempts to solve it' (Diamond, 2005, p438). In our time the inability to perceive and to solve problems is often related to our faith in technology that leads some to believe that we are masters of nature and smart enough to manage it in perpetuity. That presumption, in turn, rests on an improbably rosy view of human capabilities and the faith, as Robert Sinsheimer (1978) once put it that nature sets no traps for unwary species.

Our optimism is, I think, a product of a particular era in human history shaped by the one-time drawdown of cheap fossil fuels, the 'age of exuberance' in William Catton's words. Our politics, economics, education as well as personal expectations were shaped by the assumption that we had at last solved the age-old problem of energy. Ancient sunlight fuelled rapid economic growth, vastly increased mobility and agricultural productivity, and a level of affluence that our ancestors could not imagine. But it also weakened social cohesion, encouraged over-consumption, polluted our air and water, contaminated our politics, while creating a fragile and temporary energetic basis for the most complex human civilization ever.

Unfortunately, complex societies are vulnerable to breakdown for many reasons. Anthropologist, Joseph Tainter, summarizes these by saying that:

> as stresses necessarily arise, new organizational and economic solutions must be developed, typically at increasing costs and declining marginal return. The marginal return on investment in complexity accordingly deteriorates slowly at first and then accelerates. At this point, a complex society reaches the phase where it becomes increasingly vulnerable to collapse (Tainter, 1988, p195).

In other words, even with foresight we fail to anticipate problems which outrun solutions thereby aggregating into crises, then into a system-wide crisis of crises, the sense of care, always a limited resource, falters, human ingenuity, however considerable, fails, and things come tumbling down (Homer-Dixon, 2000). The story is an old one – lack of vision, the intoxication of power, tragedy, arrogance, stupidity and angry gods.

Toward a Design Science

The fox, it is said, knows many things but the hedgehog knows one big thing. Ecological designers, like the hedgehog, know one big thing – that everything is hitched to everything else as systems within still larger systems and patterns that connect across species, space and time. Ecological design begins in the recognition that the whole is more than the sum of its parts, that unpredictable properties emerge at different scales, and as a result that we live in a world of surprise and mystery. Those who design with nature work in the recognition that the world is one and indivisible, that what goes round comes around, that life is more paradoxical than we can ever know, and that health, healing, wholeness and holy, too, are inseparable. Ecological design is the careful meshing of human purposes with the patterns and flows of the natural world and the study of those patterns to inform human intentions, leaving a margin for error, malfeasance and the unknown. Ecological design requires an efficiency revolution in the use of energy and materials, a transition to renewable energy, changes in land use and community design, the transition to economies that preserve natural capital, and a recalibration of political and legal systems with ecological realities.

The origins of ecological design can be traced back into our prehistoric ancestors' interest in natural regularities of seasons, sun, moon and stars, as well as in the Greek conviction that humans, by the application of reason, could discern the laws of nature. Ecological design also rests on the theological conviction that we are obliged, not merely constrained, to respect larger harmonies and patterns. The Latin root word for the word religion – bind together – and the Greek root for ecology – household management – suggest a deeper compatibility and connection to order. Ecological design, further, builds on the science and technology of the industrial age, but for the purpose of establishing a partnership with nature, not domination. The first models of ecological design can be found in vernacular architecture and the practical arts that are as old as recorded history. It is, accordingly, as much a recovery of old and established knowledge as discovery of anything new. The arts of building, agriculture, forestry, health care and economy were sometimes practised sustainably in cultures that we otherwise might dismiss as primitive. The art of applied wholeness was implicit in social customs such as the observance of the Sabbath and Holy days, and the Jubilee year or the practise of potlatch in which debts were forgiven and wealth was recirculated. It is evident still in all of those various ways by which communities and societies gracefully cultivate the arts of generosity, kindness, prudence, love, humility, compassion, gentleness, forgiveness, gratitude and ecological intelligence.

In its specifically modern form, ecological design has roots in the Romantic rebellion against the more extreme forms of modernism, particularly the belief that humans armed with science and a bit of technology were lords and masters of Creation. Francis Bacon, perhaps the most influential of the architects of modern science, proposed the kind of science that would reveal knowledge by putting nature on the rack and torturing her secrets from her, a view still congenial to some who have learned to say it more correctly. The science that grew from Bacon, Galileo and Descartes overthrew older forms of knowing based on the view that we are participants in the forming of knowledge and that nature is not dead (Merchant, 1982). The result was a science based on the assumptions that we stand apart from nature, that knowledge was to be judged by its usefulness in extending human mastery over nature, and that nature is best understood by reducing it into its components pieces. 'The natural world', in the words of philosopher E. A. Burtt, 'was portrayed as a vast, self-contained mathematical machine, consisting of motions of matter in space and time and man with his purposes, feelings, and secondary qualities was shoved apart as an unimportant spectator' (1954, p104). Our minds are so completely stamped by that particular kind of science that it is difficult to imagine another way to know in which comparably valid knowledge might be derived from different assumptions and something akin to sympathy and a 'feeling for the organism' (Keller, 1983).

Among the dissidents to the directions of modern science, Goethe, best known as the author of *Faust*, stands out among the first theorists and practitioners of the science of wholeness. In contrast to a purely intellectual empiricism, what physicist and philosopher Henri Bortoft calls the 'onlooker consciousness', Goethe stressed the importance of relying on observation beginning with intuition that allowed the object being investigated to speak to the observer. Descartes, in contrast, reportedly began his days in bed by withdrawing his attention from the contaminating influence of his own body and the cares of the world, to engage in deep thinking. He aimed, thereby, to establish the methodology for a science of quantity established by pure thought. Goethe, on the other hand, practised an applied science of wholeness in which 'the organizing idea in cognition comes from the phenomenon itself, instead of from the self-assertive thinking of the investigating scientist' (Bortoft, 1966, p240).

Instead of the intellectual inquisition proposed by Bacon and practised subsequently, Goethe proposed something like a dialogue with nature by which scientists 'offer their thinking to nature so that nature can think in them and the phenomenon disclose itself as idea' (1952, p242). Facilitation of that dialogue required 'training new cognitive capacities' so that Goethean scientists 'far from being onlookers, detached from the phenomenon, or at most manipulating it externally … are engaged with it in a way which entails their own development' (1952, p244). In Bortoft's words, 'the Goethean scientist does not project their thoughts onto nature, but offers their thinking to nature so that nature can think in them and the phenomenon disclose itself as idea', (1955, p242) which requires overcoming a deeply ingrained habit of seeing things as only isolated parts not in their wholeness. The mental leap, as Bortoft notes, is similar to that made by Helen Keller who, blind and deaf, was nonetheless able to wake to what she called the 'light of the world' without any preconceptions or prior metaphoric structure whatsoever. Goethe did not propose to dispense with conventional science, but rather to find another, and complementary, doorway to the realm of knowledge in the belief that Truth is plural, not the monopoly of one method, one approach, one time or one culture.

Implicit in Goethe's mode of science is the old view, still current among some native peoples, that the Earth and its creatures are kin and in some fashion sentient, able to communicate to us, that life comes to us as a gift, and that a spirit of trust, not fear, is essential to knowing anything worth knowing. That message, in Calvin Martin's words 'is riveting … offering a civilization strangled by fear, measuring everything in fear, the chance to love everything' and to rise above 'the armored chauvinism' inherent in a kind of insane quantification (Martin, 1999, pp107, 113). It is, I think, what Albert Einstein meant in saying that:

> A human being is part of a whole, called by us the universe, a part limited in time and space. He experiences himself, his thoughts and feelings, as something separated from the rest – a kind of optical delusion of his consciousness. This delusion is a kind of

> prison for us, restricting us to our personal desires and to affection for a few persons nearest us. Our task must be to free ourselves from this prison by widening our circles of compassion to embrace all living creatures and the whole of nature in its beauty.

Goethe proposed a kind of jailbreak from the prison of Cartesian anthropocentricism and from beliefs that animals and natural systems were fit objects to be manipulated at will. His intellectual heirs include all of those who believe that the whole is more than the sum of its parts, including systems thinkers as diverse as mathematician and philosopher, Alfred North Whitehead, politician and philosopher, Jan Smuts, biologist, Ludwig von Bertalanffy, economist, Kenneth Boulding, and ecologist, Eugene Odum. Goethe's approach continues in the study of non-linear systems in places like the Santa Fe Institute. Biologist, Brian Goodwin for one, calls for a 'science of qualities' that complements and extends existing science (1994, p198). Conventional science, in Goodwin's view, is incapable of describing:

> the rhythms and spatial patterns that emerge during the development of an organism and result in the morphology and behavior that identify it as a member of a particular species … or the emergent qualities that are expressed in biological form are directly linked to the nature of organisms as integrated wholes (1994, pp198–199).

Goodwin, like Goethe, calls for a 'new biology … with a new vision of our relationships with organisms and with nature in general … [one] that emphasizes the wholeness, health, and quality of life that emerge from a deep respect for other beings and their rights to full expression of their natures' (1994, p232). Goodwin, Goethe and other systems scientists aim for a more scientific science, predicated on a rigour commensurate with the fullness of life in its lived context.

While Goethe's scientific work focused on the morphology of plants and the physics of light, D'Arcy Thompson, one of the most unusual polymaths of the 20th century and one who 'stands as the most influential biologist ever left on the fringes of legitimate science' approached design by studying how and why certain forms appeared in nature (Gleick, 1988, p199). Of his *magnum opus On Growth and Form* (1917), Sir Peter Medawar said that it was 'beyond comparison the finest work of literature in all the annals of science that have been recorded in the English tongue' (Gleik, 1988, p200). Thompson seems to have measured everything he encountered, most notably natural forms and the structural features of plants, and animals. In so doing he discovered the patterns by which form arises from physical forces, not just by evolutionary tinkering as proposed by Darwin. Why, for example, does the honeycomb of the bee consist of hexagonal chambers similar to soap bubbles compressed between two glass plates? The answer Thompson discovered was found in the response of materials to physical forces, applicable as well to 'the cornea of the human eye, dry lake beds, and polygons of tundra and ice' (Willis, 1995, p72). Thompson challenged the Darwinian idea that heredity determined all by showing the physical and mechanical forces behind life forms at all levels. His work inspired subsequent work in biomechanics, evolutionary biology, architecture and biomimicry, including that by Paul Grillo, Karl von Frisch and Steven Vogel.

Frisch, for example, explored the ingenuity of animal architecture evolved by birds, mammals, fishes and insects. African termite mounds a dozen feet high, for example, maintain a constant temperature of ~78°F in tropical climates (Frisch, 1974, pp138–149). Nests are ventilated variously by permeable walls that exchange gases and by ventilation shafts opened and closed manually as needed with no other instructions than those given by instinct. Interior ducts move air and gases automatically by convection. The system is so ingeniously designed that chambers deep underground are fed a constant stream of cool, fresh air that rises as it warms before being ventilated to the outside. Termite nests are constructed of materials cemented together with their own excretions, eliminating the problem of waste disposal. Desert termites, with no engineering degrees as far as is known, bore holes to depths of 40 metres below their nests to find sources of water. Beavers construct large dams of 1000 feet or more in length; their houses are insulated to remain warm in sub-zero temperatures. Other animals, less studied, build with comparable skill (see Tsui, 1999, pp86–131). Human ingenuity, considerable as it is, pales before that of many animals that design and build remarkably strong, adaptable and resilient structures without toxic chemicals, machinery, fossil fuels and professional engineers.

The idea that nature is shaped by physical forces as much as by evolution is also evident in the work of Theodor Schwenk who explored the role of water as a shaper of Earth's surfaces and biological systems. Of water Schwenk wrote that:

> In the chemical realm, water lies exactly at the neutral point between acid and alkaline, and is therefore able to serve as the mediator of change in either direction. In fact, water is the instrument of chemical change wherever it occurs in life and nature… In the light-realm, too, water occupies the middle ground between light and darkness. The rainbow, that primal phenomenon of color, makes its shining appearance in and through the agency of water… In the realm of gravity, water counters heaviness with levity; thus, objects immersed in water take on buoyancy… In the heat-realm water takes a middle position between radiation and conduction. It is the greatest heat conveyer in the earth's organism, transporting inconceivable amounts of warmth from hot regions to cooler ones by means of the process known as heat-convection… In the morphological realm, water favors the spherical; we see this in the drop form. Pitting the round against the radial, it calls forth that primal form of life, the spiral… In every area, water assumes the role of mediator. Encompassing both life and death, it constantly wrests the former from the latter. (Schwenk, 1989, p24)

Moving water shapes landscapes. As ice it moulds entire continents. At a micro scale, its movement shapes organs and the tiniest organisms. But at any scale it flows, dissolves, purifies, condenses, floats, washes, conducts and some believe that it even remembers. Our language is brim full of water metaphors and we have streams of thought or dry spells. The brain literally floats on a water cushion. Water in its various metaphors is the heart of our language, religion and philosophy. We are much given to the poetry of water as mists, rain, flows, springs, light reflected, waterfalls, tides, waves, storms. Some of us have been baptized in it. But all of us stand before the mystery that D. H. Lawrence called 'the third thing', by which two atoms of H and one of O become water and no one knows what it is.

'Form patterns', Schwenk wrote, 'such as those appearing in waves with new water constantly flowing through them, picture on the one hand the creation of form and on the other the constant exchange of material in the organic world' (1996, p34). Water is a shaper, but the physics of its movement is also the elementary pattern of larger systems 'depicting in miniature the great starry universe' (1996, p45). Water is the medium by which and through which life is lived. Turbulence in air and water have the same forms and mechanics as vortices whether in the ocean, atmosphere or in space. Sound waves and waves in water operate similarly. Schwenk's great contribution to ecological design, in short, was to introduce water in its fullness as a geologic, biological, somatic and spiritual force, a reminder that we are creatures of water, all of us merely eddies in one great watershed.

The profession of design as a practical art probably begins with the great British and European landscapers such as Capability Brown (1716–1783) famous for developing pastoral vistas for the rich and famous of his day. In our own history the early beginnings of design as applied ecology are apparent in the work of the great landscape architect and creator of Central Park in New York, Frederick Law Olmsted and, later, in that of Jens Jensen, who pioneered the use of native plants in landscape designs in the Midwest. Ian McHarg, a brilliant revolutionary, merged the science of ecology with landscape architecture aiming to create human settlements in which 'man and nature are indivisible, and that survival and health are contingent upon an understanding of nature and her processes' (1969, p27) His students including Pliny Fisk, Carol Franklin and Ann Whiston Spirn continued that vision armed with sophisticated methodological tools of geographic information systems and ecological modelling applicable to broader problems of human ecology.

While the degree of influence varied, many early efforts toward ecological design were inspired by the arts and crafts movement in Britain, particularly the work of William Morris and John Ruskin. In US architecture, for example, Frank Lloyd Wright's attempt to define an 'organic architecture' has clear resonance with the work of Morris and Ruskin as well as the transcendentalism of Ralph Waldo Emerson. Speaking before the Royal Institute of British Architects in 1939, Wright described organic architecture as 'architecture of nature, for nature … something more integral and consistent with the laws of nature' (Wright, 1993, pp302, 306). In words Morris and Ruskin would have applauded, Wright argued that a building 'should love the ground on which it stands' reflecting the topography, materials and life of the place (1993, p307).

Organic architecture is 'human scale in all proportions', but is a blending of nature with human created space so that it would be difficult to 'say where the garden ends and where the house begins … for we are by nature ground-loving animals, and insofar as we court the ground, know the ground, and sympathize with what it has to give us' (1993, p309). Wright's vision extended beyond architecture to a vision of the larger settlement patterns that he called 'Broadacre City', arguing that organic architecture had to be more than an island in a society with other values. In his interest on harmonizing site, form and function, and using natural materials and solar energy, in Wright is a precursor to the green building movement and the larger endeavour of ecological design. And in his often random musings about an 'organic society' he foreshadowed the present dialogue about the sustainability of modern society.

Ecological design, however, is not just about calibrating human activities with natural systems. It is also an inward search to find patterns and the order of nature written in our senses, flesh and human proclivities. There is no line dividing nature outside from inside; we are permeable creatures inseparable from nature and natural processes in which we live, move and have our being. We are also sensual creatures with five senses that we know and others that we only suspect. At its best, ecological design is a calibration, not just of our sense of proportion that the Greeks understood mathematically, but a finer calibration of the full range of our sensuality with the built environment, landscapes and natural systems. Our buildings are thoughts, words, theories and entire philosophies crystallized for a brief time into physical form that reveal what's on our mind and what's not. When done right, they are a form of dialogue with nature and our own deeper, sensual nature. The sights, smells, textures and sounds of the built environment evoke memories, initiate streams of thought, engage, sooth, provoke, bind or block, open or close possibilities. When done badly, the result is spiritual emptiness characteristic of a great deal of modern design that reveals, in turn, a poverty of thought, perception and feeling.

More specifically, we are creatures shaped inordinately by the faculty of sight, but seeing is anything but simple. Oliver Sacks once described a man blind since early childhood whose sight once restored found it to be a terrible and confusing burden preferring to return to blindness and his own inner world of touch. 'When we open our eyes each morning,' Sacks writes, 'it is upon a world we have spent a lifetime *learning* to see' (Sacks, 1993, p64). And we can lose not only the faculty of sight, but the ability to see as well. Even with 20–20 vision, our perception is always selective because our eyes permit us to see only within certain ranges of the light spectrum and because personality, prejudice, interest and culture further filter what we are able to see. Sacks notes that individual people can choose not to see and I suspect the same is true for cultures as well. The affinity for nature, a kind of sight, is much diminished in modern cultures.

Collective vision cannot be easily restored by more clever thinking, but, as David Abram puts it only 'through a renewed attentiveness to this perceptual dimension that underlies all our logics, through a rejuvenation of our carnal, sensorial empathy with the living land that sustains us' (1996, p69). Drawing from the writings of Merleau-Ponty, Abram describes perception as interactive and participatory in which 'perceived things are encountered by the perceiving body as animate, living powers that actively draw us into relation … both engender(ing) and support(ing) our more conscious, linguistic reciprocity with others' (1996, p90). Further, sight as well as language and thought are experienced bodily as colours, vibrations, sensations and empathy, not simply as mental abstractions. The ideas that viewer and viewed are in a form of dialogue and that we experience perception bodily runs against the dominant strains of Western philosophy. Plato, for illustration, has Socrates say that 'I'm a lover of learning, and trees and open country won't teach me anything whereas men in the town do' (Phaedrus, 479). Plato's world of ideal forms existed only in the abstract. Similarly, the Christian heaven exists purely somewhere beyond earthly and bodily realities. Both reflected the shifting balance between the animated sacred, participatory world and the linear, abstract, intellectual world. Commenting on the rise of writing and the priority of the text, Abram says that 'the voices of the forest, and of the river began to fade … language loosen(ed) its ancient association with the invisible breath, the spirit sever(ed) itself from the wind, and psyche dissociate(d) itself form the environing air' (1996, p254). As a result, 'human awareness folds in upon itself and the senses – once the crucial site of our engagement with the wild and animate earth – become mere adjuncts of an isolate and abstract mind' (1996, p267).

Through the designed object we are invited to participate in seeing something else, a larger reality. The creators of Stonehenge, I think, intended worshippers to see not just circles of artfully arranged stone, but the cosmos above and maybe within. The Parthenon is a temple dedicated to the goddess Athena, but also a visible testimony to an ideal existing in mathematical harmonies, proportion and symmetry discoverable by human reason. The builders of Gothic cathedrals intended not just monumental architecture but a glimpse of heaven and a home for sacred presence. For all of the crass, utilitarian ugliness of the factories, slums and glittering office towers, the designers and builders of the fourth revolution intended to reveal a world of abundance and human potentials in a world they otherwise deemed uncertain and violent, ruled by the economic laws of the jungle.

Finally, the practice of ecological design is rooted in the emerging science of ecology and the specific natural characteristics of specific places. The fifth revolution is not merely a more efficient recalibration of energy, materials and economy in accord with ecological realities, but a deeper and more coherent vision of the human place in nature. Ecological design is, in effect, the specific terms of a declaration of peace with nature that begins in the science of ecology and the recognition of our dependence on the web of life (Capra, 1996). In contrast to the belief that nature is little more than a machine and its parts merely resources, for designers of the fifth revolution it is, as Aldo Leopold put it:

> A fountain of energy flowing through a circuit of soils, plants, and animals. Food chains are the living channels which conduct energy upward; death and decay return it to the soil. The circuit is not closed; some energy is dissipated in decay, some is added by absorption from the air, some is stored in soils, peats, and long-lived forests; but it is a sustained circuit, like a slowly augmented revolving fund of life. There is always a net loss by downhill wash, but this is normally small and offset by the decay of rocks. (Leopold, 1949, p216).

Energy flowing through the 'biotic stream' moves 'in long or short circuits, rapidly or slowly, uniformly or in spurts, in declining or ascending volume', what ecologists call food chains. For designers, the important point is that the internal processes of the biotic community, the ecological books in effect, must balance so that energy used or dissipated by various processes of growth must be replenished. Leopold proposed three basic ideas:

1 that land is not merely soil;
2 that the native plants and animals kept the energy circuit open; others may or may not;
3 that man-made changes are of a different order than evolutionary changes, and have effects more comprehensive than is intended or foreseen. (Leopold, 1949, p218)

Ecological design, as Leopold noted, begins in the recognition that nature is not simply dead material or simply a resource for the expression of human wants and needs, but rather 'a community of soils, waters, plants, and animals, or collectively: the land' of which we are a part (Leopold, 1949, p204). But Leopold did not stop at the boundary of science and ethics, he went on to draw out the larger implications. For reasons of both necessity and right, the recognition that we are members in the community of life 'changes the role of *Homo sapiens* from conqueror of the land-community to plain member and citizen of it' (1949, p204). The 'upshot' is Leopold's classic statement that 'a thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise' (1949, pp224–225). We will be a long time understanding the full implications of that creed, but Leopold, late in his life, was beginning to ponder the larger social, political and economic requisites of a fully functioning land ethic.

Like Leopold's land ethic, ecological design represents a practical marriage of ecologically enlightened self-interest with the recognition of the intrinsic values of natural systems. Once consummated, however, the marriage branches out into a family of possibilities. Economics rooted in the realities of ecology, for example, requires the preservation of natural capital of soils, forests and biological diversity; which is to say economies that operate within the limits of the earth's carrying capacity (Daly, 1996). An ecological politics requires the recalibration of the complexities and timescales of ecosystems with the conduct of the public business. An ecological view of health would begin with the recognition that the body exists within an environment, not as a kind of isolated machine (Kaptchuk, 2000). Religion grounded in the operational realities of ecology would build on the human role as stewards and the obligation to care for the Creation (Tucker, 2003). An ecological view of agriculture would begin with the realities of natural systems, aiming to mimic the way natural systems function (Jackson, 1980). An ecological view of business/industry would aim to create solar powered industrial and commercial ecologies so that every waste product cycles as an input in some other system (McDonough and Braungart, 2002).

In whatever manifestation, the goal of ecological design is to go 'from conqueror of the land community to plain member and citizen of it' (Leopold). But there is no larger theory of ecological design, nor is there a textbook formula that works for practitioners across many different fields and at varying scales. And neither should we presume agreement on what it means for humankind to become a 'plain member and citizen of the biotic community'. In other words, we have a compass but no map. Architect Samuel Mockbee, founder of the Rural Studio, enjoined his students working with the poor in Hale County, Alabama, only to make their work 'warm, dry, and noble'. Warm and dry are easy for the most part because they are felt somatically, noble is hard because it requires us to make judgements about what we ought to do relative to some standard higher than creature comfort. But in the best sense of the word it is synonymous with decent, worthy, generous, magnificent, proud and resilient. And it ought to be synonymous with ecological design as well.

Ecology, the 'subversive science', begins with the recognition of our practical connections to the physical world, but it does not stop there. The awareness of the many ways by which we are connected to the web of life would lead intelligent and scientifically literate people to protect nature and the conditions necessary to it for reasons of self-interest. But our knowledge, always incomplete and often wrong, is mostly inadequate to the task of knowing what's in our interest, whether we wish to define that as 'highest' or 'lowest', let alone discerning exactly what parts of nature we must accordingly protect and how to do it. Science notwithstanding, often we do not know what we are doing and why. More subversive still are questions concerning the interests and rights of lives and life across the boundaries of species and time. Since they cannot speak for themselves, their only advocates will be those willing to speak on their behalf.

There are many clever arguments used to explain why we should or should not be concerned about those whose lives and circumstances would be affected by our action or inaction. Like so many tin soldiers, arrayed across the battlefield of abstract intellectual combat, they assault frontally or by flank, retreat only to regroup, and charge again, each battle giving rise to yet another. But in the end, I think, such questions will not be decided by intellectual combat and argumentation, however smart, but rather more simply and profoundly by affection – all of those human emotions that we try to capture in words like compassion, sympathy and love. Love, in other words, neither requires nor hinges on intellectual argument. It is a claim that we recognize as valid but for reasons we could never describe satisfactorily. In the end it is a nameless feeling that we accept as both a limitation on what we do and a gift we offer. Pascal's observation that the heart has reasons that reason does not know sums the matter. Love is a gift but the giver expects no return on the investment and that defies logic, reason and even arguments about selfish genes.

So, after all of the intellectualization and clever arguments, whether we choose to design with nature or not will come down to a profoundly simple matter of whether we love deeply enough, artfully enough, and carefully enough to preserve the web on which all life now and in the future depends. Ecological design is simply an informed love applied to the dialogue between humankind and natural systems. The origins of the practice of ecological design can be traced far back in time, but there are deeper origins found in the recesses of the human heart.

Towards Design Education

The basic principles of ecological design are these (van der Ryn and Cowan, 1996; McDonough and Braungart, 2002):

- use sunshine and wind;
- preserve diversity;
- account for all costs;
- eliminate waste;
- solve for pattern;
- protect human dignity;
- leave wide margins for error, malfeasance and ignorance.

The basic principles of modern education appear to be these:

- the purpose of education is to extend human mastery of nature;
- learning is intellectual, not emotional;
- curriculum is organized by disciplines and divisions;
- analytical reasoning (reductionism) and quantification are superior to other modes of knowing;
- schools are best organized like factories to maximize efficiency;
- success is measured first by tests, later by careers in the industrial world;
- academic architecture is a function of cost and efficiency.

The recalibration of education with ecology, and specifically one aimed to inform our role as designers, has large implications for the substance and process of education and the expectations that we bring to it. But what follows is perhaps best regarded as notes for a seminar on design education, a scouting expedition, toward that end rather than a set of firm conclusions or a blueprint.

First, in contrast to assumptions of human mastery of nature, the starting point for ecological design education is a more humble and serious consideration of the 3.8 billion years of evolutionary history. Nature, for ecological designers, is not something just to be mastered, but a tutor and mentor for human actions. Janine Benyus author of *Biomimicry* points out, for example, that spiders make biodegradable materials stronger than steel and tougher than Kevlar without fossil fuels, toxic chemicals and the product is biodegradable (Benyus, 1998). From nothing more than substances in seawater, molluscs make ceramic-like materials that are stronger and more durable than anything we know how to make. These and thousands of other examples are models for manufacturing, the design of technologies, farming, machines and architecture that are orders of magnitude more efficient, elegant and durable than our best industrial capabilities. But the foundational pedagogy begins with nature as tutor and mentor.

Ecological design, further, is not simply a mimicking of nature toward a smarter kind of industrialization, but rather a deeper revolution in the place of humans in nature. In Wendell Berry's words, design begins with questions 'What's here? What will nature permit us to do here? What will nature help us do here?' The capacity to question presumes the humility to ask, the good sense to ask the right questions, and the wisdom to follow the answers to their logical conclusions. Ecological design is not a monologue of humans talking to nature, but a dialogue that requires the capacity to listen, discern and learn from nature. When we get it right, the results in John Todd's words are 'elegant solutions predicated on the uniqueness of place'. The industrial standard, in contrast, is based on the idea that nature can be tortured into revealing her secrets, as Francis Bacon so revealingly put it. Brute force and human cleverness, not co-evolution and cooperation are at the heart of the modern worldview. So, too, standardization and a one size fits all strategy making industrial design look the same and operate by the same narrow logic everywhere. But this is no great victory for humankind because the mastery of nature, in truth, represents the mastery of some men over other men using nature as the medium, as C. S. Lewis once put it (1947).

Second, pedagogy informed by an ecological perspective does not begin with the assumption that humans are infinitely plastic. On the contrary, our sense of order and affinity for design are bounded by our long evolutionary history and our dawning sensations of life. The first safe haven we sense is our mother's womb. Our first awareness of regularity is the rhythm of our mother's heartbeat. Our first passage way is her birth canal. Our first sign of benevolence is at her breast. Our first awareness of self and other comes from sounds made and reciprocated. Our first feelings of ecstasy come from bodily release. The first window through which we see is the eye. The first tool we master is our own hand. The world is first revealed to us through the senses of touch and taste. Our first worldview is formed within small places of childhood. Our ancestors' first inkling that they were not alone was the empathetic encounter with animals. The first music they heard were sounds made by birds, animals, wind and water. Their first source of wonder, perhaps, was the undimmed night sky. Their first models of shelter were those created by birds and animals. The first materials humans used for building were mud, grass, stone, wood and animal skins. Their first metaphors were likely formed from daily experiences of nature. The first models for worship found in what early humans perceived as cosmic harmony were those of the dwelling.

We are creatures shaped by the interplay between our senses and the world around us. We know of five senses and have reason to believe that there are others. For example, some evidence suggests that we have a rudimentary awareness of being watched and there are other possibilities. Aboriginal peoples can walk with unerring accuracy across trackless landscapes in the dark of night. Across all cultures and times, good design is a close calibration of our sensuality with inspiration, creativity, place, form and materials. Good design feels right and is a pleasure to behold and experience for reasons that we understand at an intuitive level, but have difficulty explaining.

Third, all design involves decisions about how society provides food, energy, shelter, materials, water and waste cycling, and distributes risks, costs and benefits and is thereby unavoidably political. Design education, by the same logic, is political having to do with decisions about energy, forests, land, water, biological diversity, resources and the distribution of wealth, risks and benefits. Often cast as 'liberal' or 'conservative', such decisions in our time are, in fact, often about how the present generation orients itself to the interests of its children and grandchildren. One can arrive at a decent regard for their prospects as either a conservative or as a liberal. These are not opposing positions so much as they are different sides of a single coin. The point is that harmonizing social and economic life with ecological realities will require choices about energy technologies, agriculture, land use, settlement patterns, materials, the handling of wastes and water that are inescapably political and will distribute risks and benefits in one way or another.

Further, as the Greeks understood, design entails choices that enhance or retard civic life and the prospects for citizenship. But in our time 'We are witnessing the destruction of the very idea of the inclusive city' and with it the arts of civility, citizenship and civilization (Rogers, 1997, p10). By including or excluding possibilities to engage each other in convivial dialogue the creators of urban spaces enhance or diminish civility, urbanity and the civic prospect. It is no accident, I think, that crime, loneliness and low participation became epidemic as spaces such as town squares, street markets, front porches, corner pubs and parks were sacrificed to the automobile, parking lots and urban sprawl. Better design alone cannot cure these problems, but they can help to engage people with their places as thoughtful and engaged citizens.

Fourth, ecological design implies a better and more robust economics. In an age much devoted to the theology of the market, disciples of the conventional wisdom believe it imprudent to design ecologically if the costs are even marginally more than conventional design. Based on incomplete and highly selective accounting, that view is almost always wrong because it overlooks the fact that we – or someone – sooner or later will pay the full costs of bad design, one way or another. In other words, society pays for ecological design whether it gets the benefits of it or not. Honest accounting, accordingly, requires that we keep the boundaries of consideration as wide as possible over the long term and have the wit to deduct the collateral benefits that come from doing things right. For example, ignoring the costs of wars fought for 'cheap' oil, or those of climate change, air pollution and the health effects of urban sprawl, an SUV is cheap enough. But price and cost should not be confused. It is the height of folly to believe that we can eliminate forests, pollute, squander resources, erode soils, destroy biological diversity, remodel the biogeochemical cycles of the Earth, and create ugliness, human and ecological, without consequence. The truth is that, sooner or later, the full costs will be paid one way or another. The problem, however, is that the costs of environmental dereliction are diffuse and often can be deferred to some other persons and to some later time, but they do not thereby disappear. The upshot is that much of our apparent prosperity is phony and so too the intellectual and ideological justifications for it.

The application of short-term economics to architecture, in particular, has been little short of disastrous. 'The rich complexity of human motivation that generated architecture', in Richard Rogers' words, 'is being stripped bare. Building is pursued almost exclusively for profit' (1997, p67). By such logic we cannot afford to design well and build for the distant future. The results have been evident for a long time. In the mid-19th century, John Ruskin noted that 'Ours has the look of a lazy compliance with low conditions' (1880/1989, p21). But even Ruskin could not have foreseen the blight of suburban sprawl, strip development, urban decay, driven by our near terminal love affair with the automobile and inability to plan sensibly. The true costs, however, are passed on to others as 'externalities' thereby privatizing the gains while socializing the costs. The truth is, as it has always been, that a phony prosperity is no good economy at all. False economic reckoning has caused us to lay waste to our countryside, abandon our inner cities and the poor, and build auto-dependent communities that are contributing mightily to climatic change and rendering us dependent on politically unstable regions for oil.

An economy judged by the narrow industrial standards of efficiency will destroy values that it cannot comprehend. Measured as the output for a given level of input, maximizing efficiency creates disorder, that is to say, inefficiency at higher levels. The reasons are complex but have a great deal to do with our tendency to confuse means with ends. As a result efficiency often becomes an end in itself while the original purposes (prosperity, security, benevolence, reputation, etc.) are forgotten. The assembly line was efficient for the manufacturing firm, but its larger effects on workers, communities and ecologies were often destructive and the problems for which mass production was a solution have been compounded many times over. Neighbourliness is certainly an inefficient use of time on any given day, but not when considered as a design principle for communities assessed over months and years. For engineers, freeways are efficient at moving people up to a point, but they destroy communities, promote pollution, cause congestion, create dependence on foreign oil and eliminate better alternatives including design for access that precludes the need for transportation. WalMart, similarly, is an efficient marketing enterprise, but eliminates its competitors and many things that make for good communities, including jobs that pay decent wages. Success on such terms will eventually destroy WalMart and a great deal more. And, of course, nuclear weapons are wonderfully efficient and quick devices as well. Ecological design, in contrast, implies a different standard of efficiency oriented toward ends, not means, the whole, not parts, and the long term not the short term.

Fifth, design education must be grounded in an honest assessment of human capabilities. Ecological design, like all human affairs, has to be carried out in the full recognition of human limitations, including the discomfiting possibility that we are incurably ignorant. T. S. Eliot put it this way:

> Human kind
> Cannot bear very much reality. (T. S. Eliot, 1971, p119)

In other words, we are inescapably ignorant and the reasons are many. We are ignorant because reality is infinite relative to our intellectual and perceptual capacities. We are ignorant because we individually and collectively forget things that we once knew. We are ignorant because every human action changes the very system we aim to understand. We are ignorant because of our own limited intelligence and because we cannot know in advance the unintended effects of our actions on complex systems. We are ignorant even about the proper ends to which knowledge might be put. Not the least, we are ignorant, as Eliot noted, because, sometimes, we choose to be.

Alas many seem to prefer it that way. From the publication of the *Global 2000 Report* in 1980 to the present there is a veritable mountain of scientific evidence about human impacts on ecosystems and the biosphere and ways to minimize or eliminate them. But our collective sleepwalk toward the edge of avoidable tragedy continues suggesting that we are not so much rational creatures as we are adept and creative rationalizers.

Similarly, designers must reckon with the uncomfortable probability that the amount of credulity in human societies remains constant. This is readily apparent by looking backward through the rearview mirror of history to see the foibles, fantasies and follies of people in previous ages (Tuchman, 1984). For all our pretensions to rationality, others at some later time will see us similarly. The fact is that humans, in all ages and times, are inclined to be as unsceptical and sometimes as gullible as those living in any other – only the sources of our befuddlement change. People of previous ages read chicken entrails, relied on shaman, consulted oracles. We, far more sophisticated but similarly limited, use computer models, believe experts and exhibit a touching faith in technology to fix virtually everything. But who among us really understands how computers or computer models work, or are aware of the many limits of expertise, or the ironic ways in which technology 'bites back'? Has gullibility declined as science has grown more powerful? No, if anything it is growing because science and technology are increasingly esoteric and specialized and hence removed from daily experience. Understanding less and less of either, we will believe almost anything. Gullibility feeds on mental laziness and is enforced by social factors of ostracism, social pressures for conformity, and the pathologies of groupthink that penalize deviance.

This line of thought raises the related and equally unflattering possibility that stupidity may be randomly distributed up and down the socioeconomic-educational ladder. As anecdotal evidence for the latter, I offer the observation that I have likely known as many brilliant people without much formal learning as those certified by a PhD. And there are likely as many thorough-going, fully degreed fools as there are un-degreed fools. I am a professional 'educator' and an admission of such gravity leads me to think that the gift of intelligence and intellectual clarity can be focused and sharpened a bit, but can neither be taught nor conjured. The numerous examples of the under-degreed or academic failures include Albert Einstein, Winston Churchill, Frank Lloyd Wright and Amory Lovins. One should not conclude, however, that formal schooling is useless, but that its effectiveness, for all of the puffery that adorns college catalogues and educational magazines, is considerably less than advertised. And there are those as lawyer John Berry once noted who have been 'educated beyond their comprehension', people made more errant by the belief that their ignorance has been erased by the possession of facts, theories and the adornment of weighty learnedness.

Nor does the outlook for intelligence necessarily brighten when we consider the limitations of large organizations. These, too, are infected with our debilities. Most of us live out our professional lives in organizations or work for them as clients and often discover to our dismay that the collective intelligence of organizations and bureaucracies is often considerably less than that of any one of its individual employees. We are baffled by the discrepancy between smart people within organizations exhibiting a collective IQ less than, say, kitty litter. We understand human stupidity and dysfunction because we encounter it at a scale commensurate with our own. But confronted with large-scale organizations whether corporations, governments or colleges and universities we tend to equate scale, prestige and power with perspicacity and infallibility. Nothing could be farther from the truth. The intelligence of a large-scale organization (if that is not altogether oxymoronic) is limited by the obligation to earn a profit, enlarge its domain, preserve entitlements or maintain a suitable stockpile of prestige.

Our human frailties infect the design professions as well. Buildings and bridges sometimes fall down (Levy and Salvadori, 1992). Clever designs can induce an astonishing level of illness and destruction. Beyond some scale and limits design becomes guesswork. British engineer, A. R. Dykes puts it this way: 'Engineering is the art of modeling materials we do not wholly understand, into shapes we cannot precisely analyze so as to withstand forces we cannot properly assess, in such a way that the public has no reason to suspect the extent of our ignorance' (www.ukcivilengineering.co.uk/quotes.html). In various ways the same is true in other design professions and virtually every other field of human endeavour.

The point is simply to say that human limitations will be evident in every design, project and system however otherwise clever. From this there are, I think, two conclusions to be drawn. The first is simply that design, whether of bridges, buildings, communities, factories, or farms and food systems, ought to maximize the capacity of a system to withstand disturbance without impairment, which is to say resilience. Ecological design does not assume the improbable: human infallibility, technological perfection or some *deus ex machina* that magically rescues us from folly. Rather ecological designers aim to work at a manageable scale, achieving flexibility, redundancy and multiple checks and balances while avoiding the thresholds of the irreversible and irrevocable (Lovins and Lovins, 1982, ch 13; Lovins, 2002).

Forewarned about human limitations, we might further conclude that a principal goal of designers ought to be the improvement of our collective intelligence by promoting mindfulness, transparency and ecological competence. Compared to people of any other time, the public is less aware of how it is provisioned with food, energy, water, materials, security and shelter, and how its wastes are handled. Industrial design cloaked the ecological fine print of what are often little better than Faustian bargains providing luxury and convenience now, while postponing ruin to some later time. Ecological design, on the contrary, ought to demystify the world, making us mindful of energy, food, materials, water and waste flows, which is to say the ecological fine print by which we live, move and have our being.

Design is always a powerful form of education. Only the terminally pedantic believe that learning happens just in schools and classrooms. The built environment in which we spend over 90 per cent of our lives is at least as powerful in shaping our ideas and views of the world as anything learned in a classroom. Suburbs, shopping malls, freeways, parking lots and derelict urban spaces have considerable impacts on how we think, what we think about and what we can think about. The practice of design as a form of public instruction is a jailbreak of sorts, liberating the ecological imagination from the tyranny of imposed forms and relationships characteristic of the fossil fuel powered industrial age. Architecture, landscape architecture and planning carried out as a form of public education aims to instruct about energy, materials, history, rhythms of time and seasons, and the ecology of the places in which we live. It would help us become mindful of ecological relationships and engage our places creatively.

Six, awareness of human limitations might cause us, perhaps, to look more favourably on past societies and vernacular design skills created by people at the periphery of power, money and influence. The truth is that practical adaptation to the ecologies of particular places over long periods of time has often resulted in spectacularly successful models of ecological design (Rudofsky, 1964). It may well be that the ecological design revolution will be driven, at least in part, by experience accumulated from the periphery not from the centre, and led by people skilled at solving the practical problems of living artfully by their wits and good sense in particular places. The success of vernacular design across all cultures and times underscores the possibility that design intelligence may be more accurately measured at the level of the community or culture, rather than at the individual level.

Seven, in modern pedagogy, a great deal of art and philosophy has been cut off from the world of nature. The aesthetic standard for ecological design, on the contrary, reconnects to the natural world so artfully as to cause no ugliness, human or ecological, somewhere else or at some later time. The standard, in other words, requires a more robust sense of aesthetics that rises above the belief that beauty is wholly synonymous with form alone. Every great designer from Vitruvius through Frank Lloyd Wright demonstrated that beauty in the large sense had to do with the effects of buildings on the human spirit and our sense of humanity, and their impacts on specific places. But the standards for beauty must be measured on a global scale and longer time horizon so that beauty includes the upstream physical effects at wells, mines and forests where materials originate as well as the downstream effects on climate, human health and ecological resilience. The things judged truly beautiful will in time be regarded as those that raised the human spirit without compromising human dignity or ecological functions elsewhere. Architecture and landscape architecture, in other words, are a means to higher ends.

Eight, the education of professional designers requires substantial changes. As much art as science, the design professions are not simply technical disciplines, having to do with the intersection of form, materials, technology and real estate. The design professions such as architecture, landscape architecture and urban planning are first and foremost practical liberal arts with technical aspects. Writing in the first century BC, Vitruvius proposed that architects:

> be educated, skilful with the pencil, instructed in geometry, know much history, have followed the philosophers with attention, understand music, have some knowledge of medicine, know the opinions of the jurists, and be acquainted with astronomy and the theory of the heavens (1960, pp5–6).

That is a start of a liberal and liberating education. Design education, therefore, ought to be a part of a broad conversation that includes all of the liberal arts. In George Steiner's words:

> Architecture takes us to the border. It has perennially busied the philosophic imagination, from Plato to Valery and Heidegger. More insistently than any other realization of form, architecture modifies the human environment, edifying alternative and counter-worlds in relationships at once concordant with and opposed to nature (Steiner, 2001, pp251–252)

In countless ways all design, even the best, damages the natural world. Extraction and processing of materials depletes landscapes and pollutes. Building construction, operation and demolition creates large amounts of debris. Agriculture inevitably simplifies ecosystems. A new breed of ecological designers, accordingly, must be even more intellectually agile and broader, capable of orchestrating a wide array of talents and fields of knowledge necessary to design outcomes that can be sustained within the ecological carrying capacity of particular places.

Nine, education is aimed in some fashion to heal us by the systematic cultivation of reason, thoughtfulness and memory from the more egregious problems inherent in the human condition. As a further step in this progression, the design professions ought to be regarded as healing arts, an ideal rooted in Vitruvius' advice that architects ought to pay close attention to sunlight, the purity of water, air movements and the effects of the building site on human health. The word 'healing' has a close affinity with other words such as holy and wholeness. A larger sense of the profession that architect Thomas Fisher (2001) deems a 'calling', would aim for the kind of wholeness that creates not just buildings but integral homes and communities.

Compare, for example, the idea that 'architecture applies only to buildings designed with a view to aesthetic appeal' (Pevsner, 1990, p15) with architecture defined as 'the art of place-making' and creation of 'healing places' (Day, 2002, pp10, 5). In the former, design changes with trends in fashionable forms and materials. It is often indifferent to place, people and time. The goal is to make monumental, novel and photogenic buildings and landscapes that express mostly the ego and power of the designer and owner. In contrast, the making of healing places signals a larger allegiance to place that means, in turn, a commitment to the health of other places. Place-making is an art and science disciplined by locality, culture and ecology requiring detailed knowledge of local materials, weather, topography and the nature of particular places and a creative dialogue between past, present and future possibilities. It is slow work in the same sense that caring and careful have a different clock speed than carelessness. Place-making uses local resources thereby buffering local communities from the ups and downs of the global economy, unemployment and resource shortages (Sutton, 2001, p200).

Practised as a healing art, architects, for example, would design buildings and communities that do not compromise the health of people and places, drawing on the accumulated wisdom of placed cultures and vernacular skills. They would aim to design buildings that heal what ails us at deeper levels. At larger scales the challenge is to extend healing to urban ecologies. Half of humankind now lives in urban areas, a number that will rise in coming decades to perhaps 80 per cent. Cities built in the industrial model and to accommodate the automobile are widely recognized as human, ecological and, increasingly, economic disasters. Given a choice, people leave such places in droves. But we have good examples of cities as diverse as Copenhagen, Chattanooga and Curitiba that have taken charge of their futures to create livable, vital and prosperous urban places – what Peter Hall and Colin Ward (1998) have called 'sociable cities'. In order to do that, however, designers must see their work as fitting in a larger human and ecological tapestry.

As a healing art, ecological design aims toward harmony which is the proper relation of parts to the whole. As health professionals is there a design equivalent to the Hippocratic Oath in medicine that has informed medical ethics for two millennia? Are there things that designers should not design? What would it mean for designers to 'do no harm'?

Looking ahead, the challenge to the design professions is to join ecology and design in order to create buildings, communities, cities, landscapes, farms, industries and entire economies that accrue natural capital and are powered by current sunlight – perhaps, one day, having no net ecological footprint. The standard is that of the healthy, regenerative ecosystem. In the years ahead we will discover a great deal that is new and rediscover the value of vernacular traditions such as front porches, village squares, urban parks, corner pubs, bicycles, pedestrian-scaled communities, small and winding streets, local stores, riparian corridors, urban farms and wild areas, and well-used landscapes.

Design practised as a healing art is not a panacea for the egregious sins of the industrial age. However well-designed, a world of 7 to 10 billion human beings with unlimited material aspirations will sooner than later overwhelm the carrying capacity of natural systems as well as our own management abilities. There is already considerable evidence that humans now exceed the carrying capacity of Earth. Further, ecological design is not synonymous with building; often the best design choices will require adaptive reuse or more intense and creative uses of existing infrastructure. Sometimes it will mean doing nothing at all, a choice that requires a clearer and wiser distinction between our needs and wants.

What ecological designers can do, and all they can do, is to help reduce our ecological impacts and buy us time to reckon with the deeper sources of our problems that have to do with age-old questions about how we relate to each other across the boundaries and sometimes chasms of gender, ethnicity, nationality, culture and time and how we fit into the larger community of life. Ecological design, as a healing art, is only a necessary, but insufficient part of a larger strategy of healing, health and wholeness which brings us to spirit.

Finally, design education is not purely secular. For designers it is no small thing that humans are inescapably spiritual beings, but only intermittently religious. Philosopher Erazim Kohak once noted, that 'Humans can bear an incredible degree of meaningful deprivation but only very little meaningless affluence' (Kohak, 1984, p170). In the former condition most of us tend to grow, harden and mature while being undone in the latter. This is not a case for deliberately incurring misery which tends to multiply on its own with little assistance, but rather to underscore our inevitable spiritual nature that is like water bubbling upward from an artesian spring. Our only choice is not whether we are spiritual or not but whether that energy is directed to authentic purposes or not.

Much of the modern world, however, has been assembled as if people were machines, lacking any deeper needs for order, pattern and roots. Modern designers filled the world with buildings, artifacts and systems divorced from their context and living nature, and telling no story of their origins or place in the larger order of things. They seem to exist as if parachuted down from some alien realm disconnected from ecology, history, culture and place. Ecological design, on the other hand, is a process by which we become more and more rooted in a particular place and citizens in the community of life in that place. It is a form of storytelling by which buildings and landscapes and the uses we make of them artfully reveal the larger story of which they are a part. Modern design seldom tells any story worth hearing and hence fails to connect us to the nature, history and evolution of the places in which we live and work. Designers as storytellers aim to speak to the human spirit and helps ground our lives and labours in the celebration and awareness of specific places and in the larger story of the human journey (Berry, 1988).

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17

Multi-Function Agricultural Biodiversity: Pest Management and Other Benefits

Geoff M. Gurr, Stephen D. Wratten and John Michael Luna

Introduction

What good are all those species that man cannot eat or sell?

(Odum, 1971)

In structurally complex landscapes, parasitism was higher and crop damage was lower than in simple landscapes …

(Thies and Tscharntke, 1999)

The first quotation above emphasizes the potential value of species for indirect commercial production benefits (soil fertility maintenance, pollination, pest and disease suppression, etc). The second, which concerns the effect of non-crop vegetation on rape pollen beetle (*Meligethes aeneus* Fabricius) in oilseed rape (*Brassica napus* L.), neatly summarizes the type of outcome now often sought from agricultural biodiversity. In California, for example, no fewer than seven proprietary seed mixtures – with names like 'Good Bug Blend' and 'Insectary Blend' – are available to growers to increase vegetational biodiversity (Bugg and Waddington, 1994). A proprietary mixture of 'weed' species is also available in Switzerland (Nentwig et al, 1998). The consequence sought is pest suppression, ostensibly via an enhancement of the populations (or at least efficacy) of predators and parasitoids. Importantly, however, increasing biodiversity per se is no guarantee of pest suppression (van Emden and Williams, 1974; Andow, 1991; Gurr et al, 1998; Landis et al, 2000). An understanding of the mechanisms by which biodiversity may favour pest management is, therefore, important.

Vegetational diversification may be beneficial via a direct, bottom-up influence of the first trophic level on the pest. Resource concentration hypothesis effects

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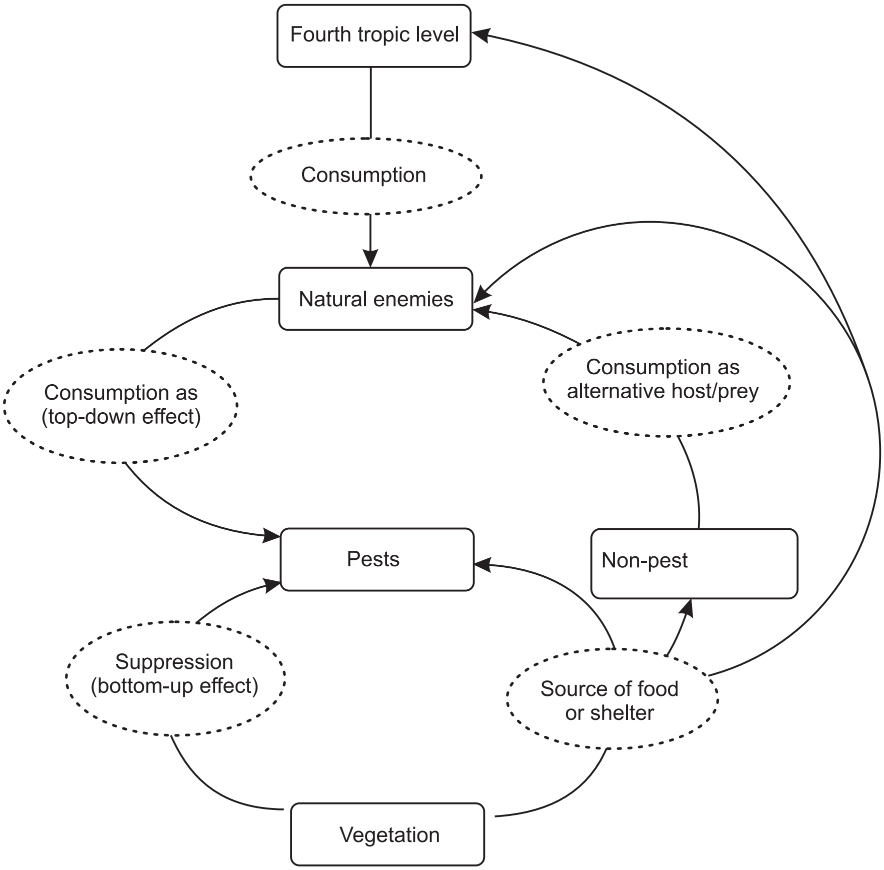

Figure 17.1 *The potential effects of vegetation on higher trophic levels and consequences for pest management*

(Root, 1973) and other mechanisms are responsible for this. Finch and Collier (2000) provide a concise review of six 'bottom-up' hypotheses, and propose a new one, the 'appropriate/inappropriate landings' hypothesis. Trap cropping (Smith and McSorley, 2000) is another potential mechanism. Pest suppression may result also from 'top-down' effects via enhancement of natural enemies (the third tropic level: Eber, 2001); conservation biological control; or Root's (1973) 'enemies hypothesis'.

In a detailed, quantitative review, Andow (1991) found that although natural enemy densities tended to be greater in polycultures than in monocultures, only slightly more than half of the 287 herbivore species were consistently less abundant in polycultures. One reason for this inconsistent effect of enhanced vegetational biodiversity is that the effects of different types of plants on natural enemies can vary markedly (Nentwig, 1992; Colley and Luna, 2000). There may also be effects on other trophic levels (Figure 17.1). For example, plants can provide resources that favour the pest (e.g. Baggen and Gurr, 1998) or members of the fourth trophic level that could then attack natural enemies of pests (e.g. Stephens et al, 1998). Despite such potential problems, there are many successful instances of biodiversity being used in agroecosystems to favour natural enemies, suppress pests and, in some cases at least, reduce crop damage (Barbosa, 1998; Gurr et al, 2000; Landis et al, 2000).

The focus of this review is the use of biodiversity to enhance pest management. We first present a concise overview of the ways in which this may be achieved. We then build on this to argue that there is a hierarchy of broader benefits to agriculture and society of enhancing biodiversity on farms. Full recognition of such multi-function agricultural biodiversity can serve only to encourage appropriate societal incentive schemes and consequent adoption by farmers.

Enhancing Biodiversity for Biological Control

The degree of complexity involved in increasing biodiversity to enhance pest management ranges from merely diversifying plant age structure within a monoculture to the opposite extreme of landscape level diversification including non-crop and perennial vegetation (Table 17.1).

Often, attempts to diversify agroecosystems remove or reduce the negative aspects of the features that typify modern, industrialized farming. These features include the removal or degradation of non-crop habitats such as hedgerows, woodland and riparian vegetation; use of monocultures; almost total weed removal from within and around crops; large field sizes; and tillage operations of varying degrees of intensity (see Jepson, 1989 and Dent, 1995 for more details).

Diversification within a monoculture

Monocultures dominate modern, industrialized agriculture. Farmers tend to be risk-averse (Norton, 1976, 1993). This has led to some attempts to enhance pest management by making only subtle changes to normal management. In a recent example, strip-cutting of lucerne (*Medicago sativa* L.) was tested as an alternative to the normal practice of harvesting entire fields at a time (Hossain et al, 2001). In this system, natural enemies migrated from harvested strips into adjacent, unharvested ones. When these refuges were cut some weeks later, natural enemies moved into the regrowing strips. Alternating harvests over the course of the haymaking season (spring–autumn) preserved within-field habitats favourable to natural enemies and contributed to the suppression of pests (*Helicoverpa* spp.: Lepidoptera).

‘Relaxing’ the monoculture

A slightly more complex form of diversification involves growing two or more varieties or closely related species of crop. This approach is well-known to plant

Table 17.1 *Examples, with increasing levels of complexity, of biodiversity enhancement benefiting pest management*

Level of complexity	*Nature of diversification*	*Example*
Diversification within a monoculture	Make crop itself structurally more diverse	Alternating harvests of lucerne strips to give structural diversity and preserve habitat for natural enemies of *Helicoverpa* spp. (Hossain et al, 2001)
'Relax' the monoculture	Grow a mix of varieties or closely related species	Willow beetle numbers and damage reduced in mixed plantings of willow (Peacock and Herrick, 2000)
Allow non-crop vegetation within the monoculture	Allow weed growth within areas of the crop	Weed strips increase natural enemy density (Lys et al, 1994)
Diversify vegetation bordering the monoculture	Sow non-crop vegetation in field margin	Phacelia strips beside wheat as pollen source for hoverfly, natural enemies of aphids (Hickman and Wratten, 1996)
Abandon monoculture	Grow two or more crops within the field	Lucerne strip within cotton act as decoy for mirids and habitat for natural enemies of cotton pests (Mensah and Kahn, 1997)
Diversify vegetation beyond the field margin	Sown or naturally generated vegetation in fallow fields adjacent to crops	'Complex, structurally rich … large old fallows' adjacent to rape increased parasitism of rape pollen beetle and reduced crop damage (Thies and Tscharntke, 1999)
Farm-wide diversification	Agroforestry integrated with cropping and livestock	Increasing arthropod densities by use of a 'silvoarable agroforestry system' (Peng et al, 1993)
Landscape level changes	Landscapes with areas of woodland	Parasitism rates of armyworm lower in crops within complex landscapes (Marino and Landis, 1996)

pathologists as a way of slowing the spread of diseases (e.g. in rice, Wolfe, 2000), but its potential impact on insect pests is illustrated by a recent study of the willow beetle (*Phratora vulgatissima* (L.)). Beetle density, oviposition and damage were lower in mixtures of up to five willow (*Salix* spp.) varieties and species than in monocultures (Peacock and Herrick, 2000). This example illustrates that enhancement of natural enemy density is not a prerequisite for effective pest management. Its findings are consistent with the resource concentration hypothesis.

Within-field non-crop vegetation

A second characteristic of industrialized agriculture is active weed control, generally through the use of herbicides. Removal of weeds can be antagonistic to arthropod pest management. Often these non-crop plants contribute towards the resource concentration hypothesis effect. They may also favour natural enemies by providing non-host foods such as pollen and nectar, support non-pest alternative hosts or prey, and provide shelter or a moderated microclimate. Reintroducing some weeds in ways that are agronomically acceptable to farmers can restore some of the 'ecosystem services' they provide to natural enemies (Nentwig et al, 1998). In the latter study, 1.5m-wide strips of weeds used at 24m intervals within cropped areas favoured natural enemies such as syrphids, chrysopids and coccinellids. An alternative approach is to withhold all or some herbicide application in part of the crop and allow growth of the existing weed community. The headland (the area of the field in which farm machinery turns and crop productivity is often lower because of the resulting soil compaction) has been used in this manner. In British work, such 'conservation headlands' provided pollen sources for adult syrphids, *Episyrphus balteatus* (Degeer) (Cowgill et al, 1993). This resulted in a significant positive relationship between number of syrphid eggs per aphid and the density of weeds.

Genetically modified herbicide resistant crops could increase within-crop botanical diversity and invertebrate biodiversity if farmers used the technology to apply herbicides after *crop* emergence and only if weed density justified spraying. This approach contrasts with the currently common practice of prophylactic application of pre-emergent herbicides, which is necessary because many weed species are impossible to kill selectively after crop emergence. There will, however, be a temptation to use herbicide resistant crops as an opportunity to exercise more stringent levels of weed control than in conventional crops. This would have a negative impact on biodiversity.

Diversification can apply also to perennial crop systems such as orchards and vineyards, where vegetational structure can include a distinct understorey. A considerable amount of work has taken place examining the effects of this relatively common form of diversification and it is particularly widely practised in China. The ground cover plant *Ageratum conyzoides* L. (Asteraceae) has been planted or conserved in 135,000ha of citrus where it is claimed to stabilize populations of *Amblyseius* spp., predators of the citrus red mite, *Panonychus citri* McGregor (Liang and Huang, 1994).

Plants other than 'weeds' may also be introduced as strips within the area of crops. 'Beetle banks', low ridges sown to perennial, tussock forming grasses have been used in British and mainland European arable crops for over a decade to provide overwintering habitat for natural enemies of aphid pests (Thomas et al, 1991; Thomas and Goulson, 2000). Migration of predatory beetles and spiders from these habitats into the crop in the spring supplements those from the field margin. Further, because beetle banks run through the centre of fields, predators migrating from them have immediate access to regions of the crop remote from the field boundary. Many important species are non-aerial so would otherwise be slow to colonize the entire area of the large fields that are now so common. Beetle banks generate high densities of polyphagous predators. Modelling and exclusion work has shown that such natural enemies can reduce aphid densities in cereals (Chiverton, 1986; Winder et al, 1988; Winder, 1990).

Field margin non-crop vegetation

An extension of this use of non-crop vegetation is its placement adjacent to the crop within the field margin. Most commonly, nectar- or pollen-rich plants are used with the former benefiting parasitoids (e.g. Baggen and Gurr, 1998) and the latter benefiting hoverflies (e.g. Hickman and Wratten, 1996). Importantly, however, tall boundary vegetation, such as trees, may impede hoverfly dispersal into nearby areas of crop (Wratten et al, in press). Thus, habitat structure may constrain the spatial extent of the benefits from adding floral resources to existing boundaries.

Abandoning monoculture

Greater levels of complexity in diversification may be seen when monoculture is abandoned and intercropping and similar practices, in which one or more additional crop species are grown within the field, are used. This may take a variety of forms ranging in complexity from the simple inclusion of a discrete area of a secondary crop to complex spatial or temporal patterns of polycultures.

An example of a simple departure from monoculture is the use of a lucerne strip within Australian cotton crops. The effects of this were two-fold. First, the lucerne is ‘preferred’ over cotton by the green crop mirid (*Creontiades dilutus* Stal) so it acts as a decoy or trap crop. Second, lucerne provides a habitat suitable for a diverse suite of natural enemies and movement of these into the cotton crop during a pest outbreak can be achieved by mowing the lucerne or applying an attractive food spray to the cotton (Mensah and Kahn, 1997).

Dramatic trap-crop results have been obtained by drilling white or black mustard (*Sinapis alba* (L.) and *Pisum sativum* (L.)) in the outer few metres of sweet corn (*Zea mays* L.) fields in New Zealand (Rea et al, in press). The green vegetable bug (*Nezara viridula* L.) normally invades the crop from surrounding vegetation. In this work, the bugs remained in the mustard, feeding on its developing pods, and this allowed the sweet corn to reach harvest stage with virtually no damage.

Another approach to conserve and enhance diversity of agroecosystems involves the use of conservation tillage. Cover crops or existing vegetation can be suppressed with herbicides and crops direct-seeded into the residue. This form of relay intercropping has increased diversity of generalist predators (Clark et al, 1993). The use of legume cover crops as living mulches in strip tillage or relay interplanted systems is another approach that increases biodiversity in agricultural ecosystems. Dempster and Coaker (1974) found that the maintenance of clover cover between rows of brassica crops reduced populations of three insect pests (*Brevicoryne brassicae* L., *Artogeia rapae* (L.) and *Erioischia brassicae* Bouché). In an experiment involving several living mulches interseeded into cabbage, Andow et al (1986) showed that living mulches reduced populations of the flea beetle (*Phyllotreta cruciferae* Goeze) and *B. brassicae* compared with monoculture plantings of cabbage. In Hawaii, Hooks and Johnson (2001) interplanted broccoli (*Brassica oleracea* L.) with chilli pepper (*Capsicum annuum* L.) or yellow sweetclover (*Melilotus officinalis* L.). The latter treatment led to fewer Lepidoptera larvae in the broccoli heads compared with the sweet pepper or control treatments and the broccoli heads did not differ in size. Undersowing with legumes such as clover to improve soil fertility, is a traditional practice. Its potential for maintaining invertebrate and bird biodiversity has only more recently been realized (Firbank et al, 1996).

Diversification beyond the field scale

At a greater level of complexity, changes may be made that apply beyond the field boundary. The work on the effects of adjacent vegetation on rape pollen beetle from which the opening quotation was taken provides an example (Thies and Tscharntke, 1999). Oilseed rape crops with simple and structurally poor adjacent vegetation were more severely damaged by this pest and it suffered lower rates of parasitism than those observed in crops adjacent to 'complex, structurally rich … large old fallows'.

At a still larger spatial scale, potentially extending beyond the farm boundary, features such as areas of woodland and hedgerow can have a long-range effect on rates of parasitism of crop pests. In a study that compared 139 fields in a 3.2km^2 area of 'complex' landscape with 61 fields in a similar area of 'simple' landscape, the lepidopteran armyworm, *Pseudaletia unipunctata* Haworth, was parasitized at a statistically higher rate in the crops located in the former (Marino and Landis, 1996).

Benefits of Biodiversity – a Hierarchy of Scales

As is clear from the foregoing examples, enhanced agricultural biodiversity can favour pest management *via* enhanced biological control or direct (resource concentration hypothesis) effects on pests. However, benefits beyond this 'pathosystem' scale are also possible and these may be viewed in a hierarchical fashion (Figure 17.2).

Clearly, the effects of biodiversity on pests and their natural enemies have the potential to benefit the crop. However, crop production may also benefit in other ways. These effects may extend both spatially to adjacent crops and temporally to subsequent crops, so increasing the sustainability of the farming system. Benefits may also influence other, non-crop habitats both on-farm and more extensively, so lessening the environmental impact of farming and bringing other benefits to

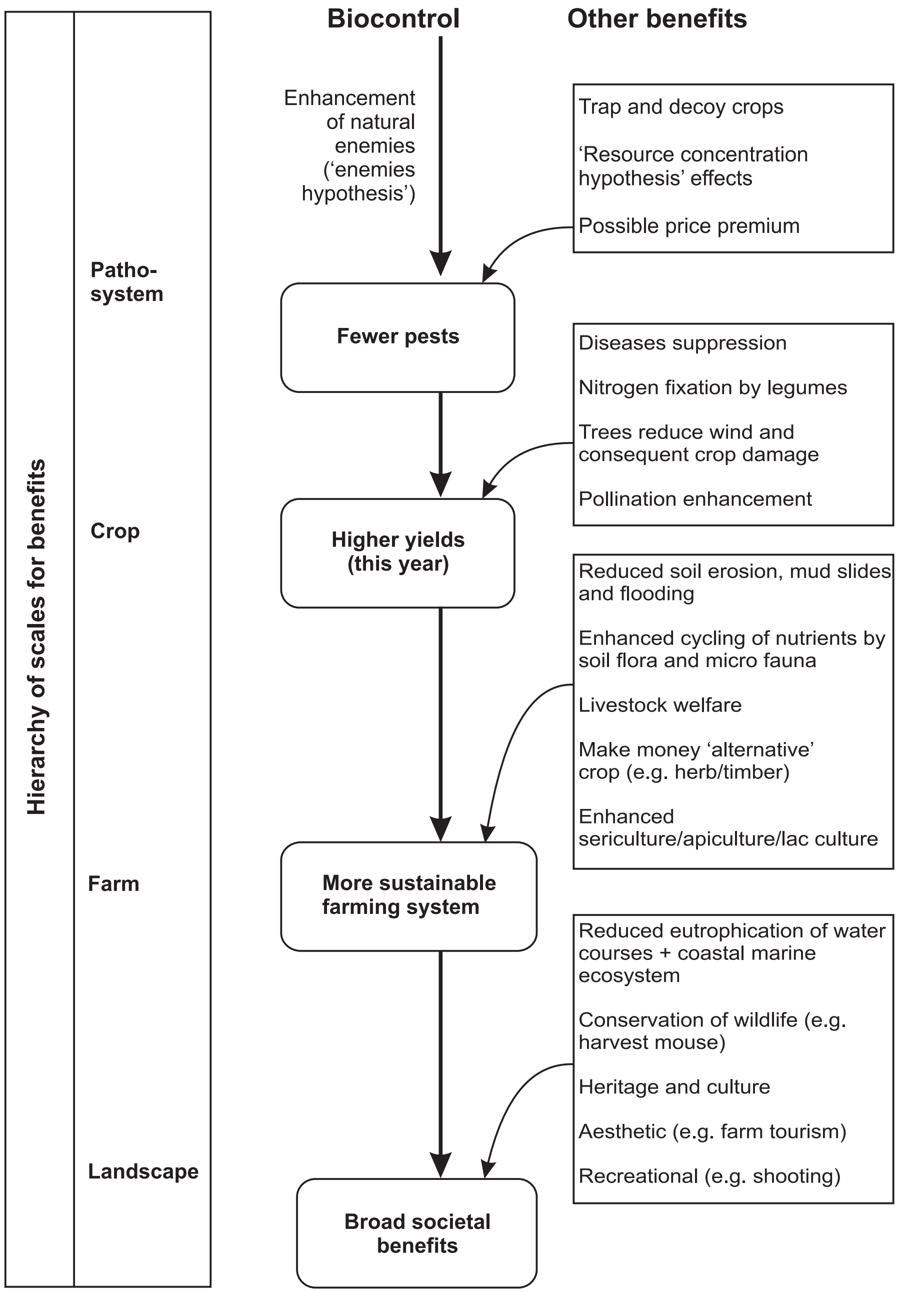

Figure 17.2 *The hierarchy of scale for potential benefits of multi-function agricultural biodiversity*

society. A detailed analysis of benefits at all these levels is beyond the scope of this paper. The argument that will be developed here is that when biodiversity is increased in an attempt to benefit pest management, there may also be a cascade of outcomes at these other hierarchical levels. The following examples develop this concept of multiple-function agricultural biodiversity.

Crop scale benefits

In instances where agricultural biodiversity has reduced pest densities, the need for pesticide inputs may be lessened although linking increased biodiversity to higher yields through pest suppression is very difficult to demonstrate (Gurr et al, 2000). This can have a spectrum of benefits, of which the most immediate is financial. Probably the most detailed financial analysis of the benefits and costs associated with introducing diversity for pest suppression is that by Thomas et al (1991). The cost of establishing a 'beetle bank' in a 20ha wheat field, combined with the value of yield lost through land taken out of production, was calculated to be US$130. However, the value of keeping aphid pest densities below the action threshold was estimated to be US$450, and the value of avoiding a 5 per cent aphid-induced yield loss was US$1000. Such figures illustrate the potential for significant economic benefits from increasing biodiversity. Potential additional advantages apply when pesticide inputs are reduced (in an Integrated Pest Management (IPM) scheme, for example) or almost completely removed (as in organic agriculture). Premium prices may be attracted for produce grown under such systems (Govindasamy and Italia, 1997) or market share can be increased because of the benefits perceived by the consumer.

Even in cases where there is no change in pesticide use, there is scope for economic benefits to the grower if crop quality and/or yield is improved. Theunissen et al (1995), for example, investigated the effects of intercropping cabbage (*Brassica campestris* L.) with white or subterranean clover (*Trifolium repens* L. and *T. subterraneum* L., respectively). In this work, the densities of various natural enemies were increased in interplanted treatments compared with the monoculture control. Densities of pests such as the cabbage moth (*Mamestra brassicae* L.) were lower in intercrop treatments and, although the total yields of the cabbage were lower in these crops as a result of plant competition, the quality of cabbages was greater as a result of lower pest damage. The effects of the diversification were, therefore, calculated to be economically favourable.

Aside from the direct effects on arthropods described above, diversification may benefit crop production in a variety of ways. The impact of bird pests and plant diseases can be reduced by aspects of vegetational diversity (Jones (1974) and Bridge (1996) respectively). Weed densities also may be reduced, as in a recent study of the effects of increased biodiversity in rice. When weeds were retained on the bunds surrounding paddies, this vegetation supported not only natural enemies of pests but also seed-collecting ants that had the effect of reducing numbers of weed seeds within paddies (Upawansa, 1999). More broadly, the vegetated bunds were more resistant to damage from floods and wild animals and were claimed to save labour and money.

In cases where biodiversity has been increased by the introduction of a leguminous plant (e.g. Theunissen et al, 1995) atmospheric nitrogen will be fixed. This important plant nutrient will be available to the diversified crop or the next crop in the rotation (Altieri, 1994). As well as directly benefiting plant growth, this effect may also be involved in the effects on host plant quality that were concluded to be important in accounting for reduced densities of *Thrips tabaci* Lindeman on leeks interplanted with clover (Belder et al, 2000). The structure and management of agricultural vegetation may also have effects on soil flora and benefit soil productivity (Hawksworth, 1991). Agroforestry, for example, supports a greater abundance of mycorrhizal fungi than does monoculture (Boddington and Dodd, 2000), and biological control of plant pathogens and nematodes can be enhanced by 'suppressive soils' – those with high microbiological activity (Whipps and Davies, 2000).

Another benefit of vegetational biodiversity is the conservation of pollinating insects that are important in many dicotyledonous crop species (Mineau and McLachlin, 1996). The occupancy rate of bumblebee domiciles was greatest in more diverse habitats (Barron et al, 2000). Overall, biodiversity can have a variety of benefits at this level of a specific diversified crop.

Farm scale benefits

The next level at which biodiversity may be beneficial is beyond the specific crop being manipulated. It considers other components of the farming system such as the intrinsic value of the introduced vegetation, impacts on adjacent but un-manipulated crops and effects on livestock within the farming system.

In instances where biodiversity is increased by adoption of some form of intercropping, the additional crops will have an added value, through their harvest being economically worthwhile. Examples include hay made from lucerne strips grown within cotton (Mensah and Kahn, 1997) or timber from agroforestry (Chitra and Solanki, 2000). There may also be complementary production benefits, such as supporting apiculture, sericulture or lac culture (Chitra and Solanki, 2000). At least some of these may apply even when the non-crop vegetation is not for harvest, for example in the case of hedges or woodland. It is also recognized that integrating trees into pastoral systems may have benefits for welfare of livestock animals via shelter from wind and provision of shade (Sinclair, 1999), as well as providing aesthetic (e.g. landscape), recreational, conservation and other advantages.

Landscape scale benefits

At this level, biodiversity may have a variety of benefits. Beetle banks and conservation headlands, both examples of vegetational diversity where increases in natural enemy density have been recorded (Thomas et al, 1991; Hassall et al, 1992; Cowgill et al, 1993) provide considerable conservation benefits. A variety of birds and small mammals use this habitat, as well as grassy field margins, and the invertebrate and plant foods it supports (Bence et al, 1999). Some animals, such as the hare (*Lepus europaeus* Pallas) and the grey partridge (*Perdix perdix* L.), are valued as game species, so provide a recreational benefit as well as additional revenue for the landholder (Boatman, 1999). Other species are of conservation significance and include the skylark (*Alauda arvensis* L.) and harvest mouse (*Micromys minutus* (Pallas)). Harvest mouse nest densities on 'beetle banks' were 47/km compared with only 5/km in field margins (Bence et al, 1999). Although some such species may be rarely encountered by members of the general public, there is considerable societal benefit in the knowledge that they do still exist ('existence value'). More tangible aesthetic benefits of biodiversity are evident in the preservation of an attractive farming landscape in which tourism and recreation can take place. Further, in countries such as Australia, New Zealand and the US, the heritage and culture of the aboriginal peoples has been threatened by land use practices introduced by European settlers. Under these circumstances, the introduction of biodiversity provides an opportunity to preserve plants of cultural significance. These may include plants of food, fibre, ceremonial and medicinal value (Patterson, 1992; Anon, 1994).

A contrasting, environmental benefit of enhanced vegetational biodiversity is the prevention of soil erosion by wind and water. The vegetationally diverse 'corridors' that Rodenhouse et al (1992) found to enhance natural enemies of soybean pests were considered to have the additional benefit of constituting a barrier to soil movement. Any such effect would, in turn, help reduce eutrophication of waterways by minimizing inputs of nutrients such as nitrogen and phosphorus and preserve sources of water for human use (Edwards and Abivardi, 1998).

At the ultimate spatial scale, biodiversity in agriculture can aid carbon sequestration (Nair, 1998). Annual carbon dioxide uptake of individual trees can be in the order of 150kg, a benefit valued at US$5 tree/year (McPherson et al, 1999).

Conclusion

The examples outlined above illustrate that when biodiversity is increased, several benefits may result at more than one hierarchical level, and thus multiple-function agricultural biodiversity is achieved. Importantly, however, because of the reductionist tendency in scientific research, many of the benefits will not have been quantified or even recognized.

Exploration of multi-function agricultural biodiversity is an important future research theme in sustainable agriculture because many farmers will be persuaded to conserve existing biodiversity and introduce additional biodiversity only if convinced to do so by a tangible package of economically rational as well as aesthetic benefits. Establishing the types and extents of these various benefits will demand a greater degree of collaboration between researchers from disciplines including pest management, soil science, wildlife ecology, economics, anthropology and social science. It is to be hoped that this special issue will spur such work.

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18

Generating Community Change

Cornelia Butler Flora and Jan L. Flora

When Sue James and her husband Bart moved with their two teenage children to New Richland, Minnesota, from St. Louis, Missouri, they eagerly anticipated the prospect of the clean air and neighbourliness found in rural America. Big-city living had lost its lustre, and they were excited to live in the 'country'. However, a few months after their move, they realized they missed certain elements of living in a larger setting, particularly in terms of recreation. Furthermore, there were few summer jobs for teenagers in a small, rural area.

Bart and Sue often went to a small, locally owned diner for breakfast and coffee on Saturday mornings, and they met many farmers and businesspeople who lived in the town. Bart, being the new school superintendent, was a familiar face already. Bart mentioned his family's love of golf, and several other community members agreed that they wished there was a course in town. Word spread, and soon Bart and Sue decided to open the idea up for town consideration.

First, they placed a notice in the local paper announcing an open meeting to discuss construction of a community golf course; 40 people attended. Committees were set up to consider possible sites and organizational structures. At the next meeting, more than 100 people were present. Interest in the project proliferated, and it helped that all of the meetings were well covered in the local paper.

The site committee presented four potential sites, which in the following weeks were visited by most of the members of the town, even those who did not play golf. At the next community meeting, with several hundred people in attendance, the pros and cons of each site were presented. With all of this information in mind, the assembly voted on the site they wanted. The site that was chosen would be purchased from its owner, a farmer who agreed to sell at the market price for agricultural land. The local community development corporation, established in the early 1970s, was utilized to raise money for the project, and in just two months the purchase price was raised through donations and by selling local shares in the golf course to community members.

The layout of the golf course was designed, and local farmers donated time and equipment to help the city do the necessary construction, including building two wells, one for the clubhouse and one for the fairways and greens. A separate community golf course corporation was established, a manager–golf professional was hired, and the club was off and running! A local couple established a concession stand at the course, and the golf pro set up a pro shop. Students found work in the summers as groundskeepers and caddies, local people were now able to play (and many learned the game), and the course proved to be an attraction for out-of-town players, who found its riverside location attractive and the well-kept nine holes pleasurable to play.

Sue and Bart began to feel like an integral part of the community due to their participation in the creation of the golf course. The community has an additional asset in terms of investing in themselves, and the economic benefits to the community through the creation of new jobs and the attraction of outsiders to the community have proven to be unanticipated benefits of the project.

Community development occurred in New Richland because of the community's ability to identify its assets – including levels of bridging and bonding social capital – and to invest them in themselves. They were able to mobilize many sectors of the community to work together to make things happen. In New Richland, with its history of self-investment and community participation, such activities were relatively easy to undertake. Economic development was one of the results, but not the major motivation for the project.

In other communities, community change seems almost hopeless. New people move to town with great dreams for community improvement, but their dreams never materialize. Or local residents concerned about a declining economic base seek to attract industry, with ever-decreasing likelihood of success. What makes the difference between towns that develop and change in response to felt needs and those that seem unable to respond effectively to the current climate of economic deterioration in most rural areas? What are the components of community development, and what makes it happen?

This chapter centres on three models of community development. The assumptions behind them are followed by illustrations of how they can and have been implemented. The three models are then compared in terms of their linkages to the outside and their approaches to the planning process. Then two approaches to economic development are introduced and related to the three models of community development.

Community and Economic Development

The word 'community' comes from the Greek word for 'fellowship'. Fellowship involves interaction. Hence, *community development* implies that the quality of interaction among the people living in a locality improves over time. Such interaction both depends on and contributes to enhanced quality of life for each member of the community: better housing, better education, enhanced recreational and cultural opportunities and so on. Central to the concept of community development is the idea of *collective agency*. Collective agency is the ability of a group of people – in this case those living in the same community – to solve common problems together. For community development – and collective agency – to occur, people in a community must believe that working together can make a difference and organize to collectively address their shared needs.

Community development is much broader than economic development. Indeed, one could argue that economic development could be antithetical to community development for two reasons: economic development does not necessarily involve collective agency, and economic development may not result in an improvement of the quality of life. For instance, the high rates of economic growth in the 'boom towns' have a negative impact on community development. The incomes of some members of the community may increase, but as crime rates increase, schools become overcrowded, housing prices soar and neighbourliness declines, the quality of life for the majority of the residents may deteriorate. This is particularly true when economic growth in the community is triggered by an absentee firm, whether it is an oil or coal company, a national meatpacker, a recreational conglomerate or a transnational manufacturing company.

When we look at community development, we will focus on what local people do to improve the overall quality of life of the community. In the difficult economic times of the 1990s and 2000s, economic development was and is seen as the dominant means for community betterment. But bringing in jobs is not enough. And bringing the wrong type of jobs may decrease the community's quality of life. We will now examine approaches taken by community members and leaders to improve their collective well-being and how these approaches relate to collective agency.

Models of Community Development

Community problem solving does not take place automatically, even in a community like New Richland. Problems have to be identified, potential solutions considered, organizational means put in place and resources mobilized. There are a number of models of community development that can facilitate this happening. Let us look at alternative models of community organization to see which might serve in different types of communities.

Three major approaches to community development have been laid out by James Christenson (1989): the self-help, technical assistance and conflict models. Each of the different approaches identifies a different role for the change agent, a different orientation to task versus process, different clientele, a different image of the individual, a different conception of the basis of change, a different core problem to be addressed and a different action goal.

Self-help model

The *self-help* model emphasizes process: people within the community working together to arrive at group decisions and taking actions to improve their community. The process builds civic capacity for collective action to move toward a shared vision for the future of the community. In this model of community development, the aim is not so much to complete a particular project as to institutionalize a process of change based on building community institutions and strengthening community relationships to work toward desired future conditions. The New Richland golf course contains major elements of self-help community development because putting it into place involved reinforcing patterns of community interaction, cooperation and decision making. The change agents, the school superintendent and his wife, acted as facilitators for community input rather than sources of infinite knowledge about golf courses. People viewed the development of the golf course as something they had decided together rather than as the result of the best technical advice. The people involved in New Richland were definitely middle class. Both those who play golf and those who have the means to contribute equipment or invest in shares in a community corporation tend to be better off. And the community has developed new ways of working together to bring about an improved, shared future.

It took a while to instigate the golf course project due to the large number of meetings required to obtain everyone's input, form the appropriate committees and respond to each committee's reports and suggestions. Yet once the golf course was established, it easily became part of the public agenda in terms of local participation in running it and in convincing city government to participate in its maintenance.

However, if the New Richland project had been a purely self-help effort, the initiators would have begun with a more diffuse goal, such as increasing recreational opportunities in the community. The decision to build a golf course – or an alternative recreational facility, such as a lighted softball diamond – would have been part of the process rather than the reason for devising the process. There are a number of assumptions about the nature of rural communities behind the self-help model (discussed by Littrell and Hobbs, 1989). When these assumptions about the structure of the community are wrong, self-help as a strategy will be difficult to implement. These assumptions include these: (1) that communities' members have a similarity of interest and that community development involves building consensus, (2) that generalized participation and democratic decision making within the community are necessary and possible, and (3) that the community has a degree of autonomy such that community actors can in fact influence the community's destiny.

A central assumption in the self-help model of community development is that communities are homogeneous and based on consensus. In fact, despite the norm of 'we're all just folks' endorsed in many rural communities, most communities have increasing disparities in income and access to other resources. Thus, development efforts, which depend on existing local leaders as a basis for community organizing, may systematically bias development efforts away from the problems of the least-advantaged citizens. That bias, in turn, can give rise to increased inequalities and increasing poverty or to conflict-based community development activities. In fact, interests within communities can conflict.

Participation and democratic decision making are essential to the self-help model of development. The self-help approach assumes that it is indeed possible to motivate a broad-based band of community members to participate in community affairs. However, if community residents are uninterested and unmotivated and do not want to become involved, participation will not take place. Some groups of local residents will not see the community as relevant to their welfare, as happens, for example, with some farmers who feel their well-being depends almost entirely on government programmes. Thus, these farmers may simply bypass the community and be actively involved only in their commodity organizations, which focus on the national and not on the community level. If in a particular community no farmers are active participants in efforts to solve community problems, broad-based community participation can be said not to exist, for one important segment of the community is uninvolved.

The time commitment mandated by the self-help approach may cause many to drop out, which threatens the processual aspects of this approach. Even if the stated objectives of the community development effort are reached, the effort cannot be said to have been successful if participation in the process was minimal. The approach cannot be used to solve another community problem because no new means of interaction and quality of interaction were enhanced. In a word, the process was not institutionalized, and, from the self-help point of view, the effort was not successful. One obstacle to effective use of the self-help approach in small towns is the fact that people know each other in too many roles. Thus, the risk of taking a public stance, which is sometimes necessary for effective discussion, may result in public disagreement with a boss, a customer or a colleague. This risk is seen as too great in many small towns.

Furthermore, different segments of the community have different levels of participatory skills. Higher education and professional employment give a disproportionate voice to the more privileged segment of any community, in part because they have experience with participation. And middle-class youth are raised with verbal and discussion skills, whereas obedience – until a situation involving confrontation arises – is part of working-class socialization patterns.

Finally, self-help models of development assume a significant degree of community autonomy. Yet as we have shown in earlier chapters, rural communities are highly involved in regional, national and even international networks that have enormous impacts on them. Being dependent on the global economy, however, does not mean that it is useless for communities to undertake self-help activities. But it does make it important that the global economic trends are understood. Part of the process of the self-help model therefore includes community education on the community's place in the global economy and the current trends within it.

The case of Ivanhoe, Virginia, illustrates this point. The first effort of the Ivanhoe Civic League following its founding in the mid-1980s was to gain control of a shell building from the county government in the hope that the community would be able to attract an industry to occupy the building. Following major efforts to obtain an industry, the Civic League concluded that adult education and youth programmes would be more beneficial to the community. By the year 2003, the Ivanhoe Civic League continues to work to make Ivanhoe a better place for all of its citizens. The education programme consists of community-based Adult Basic Education/General Education Development (ABE/GED). The Ivanhoe Civic League's education programme offers college classes, youth tutorials that include guidance on college and careers, professional development workshops and computer and adult literacy classes. In 1993, a vocational component rehabilitated a historic structure in Ivanhoe to provide office and education facilities for the Ivanhoe Civic League.

The citizens of Ivanhoe decided that the assets of their community – their culture and the beautiful setting – should be shared by those who share their vision of a positive future for the community. In the mid-1990s, the Ivanhoe Civic League inaugurated the Volunteers for Communities, now a separate organization, which is currently training 17 communities throughout the region to host volunteers. Community service and celebration continue to play a major role for the Ivanhoe Civic League. They host an annual all-community Christmas party, a Thanksgiving Prayer Service and a week-long Jubilee festival, as well as many other community events. They built bonding social capital to help determine the vision and built bridging social capital to mobilize resources to be locally invested for an Ivanhoe where young people and elders prospered together.

Coaching: A new approach to self-help

Although self-help assumes that most of the assets for change will come from the inside and that the energy for change will be generated from within, a number of experiences show how coaches and facilitators can act as brokers to identify assets and passions within the community and link them with appropriate collaborators to achieve entrepreneurial visions (Sirolli, 1999) or community visions (Rubin, 2001, p497). Box 18.1 shows how coaching and a strategic visioning process helped a community college–community team move toward equitable economic development.

Technical assistance model

In contrast to the self-help model, the *technical assistance model* stresses the task that is to be performed. A few local leaders might decide that the community needs a golf course. After talking among themselves in private, they call in technical experts to assess the local situation and to find the most efficient way to build and run a golf course. The construction of the course might require receiving

Box 18.1 *A holistic approach to positive community change: The Rural Community College Initiative (RCCI)*

Southeast Community College in Cumberland, Kentucky, illustrates what team building, strategic visioning and coaching can accomplish. Southeast's RCCI employed a vision-to-action (MDC Inc, 2000) team to generate and spin off community development and education initiatives. The team includes the college president and selected faculty and staff members, business owners, a banker, a former coal miner, elected officials, grassroots leaders, K–12 teachers and administrators, and human service agency staff members. This diverse, yeasty mix of folks, who before RCCI had not worked together, has looked hard at community issues, come up with innovative ways of recombining community assets, and brought in the resources and partners needed to implement new projects.

Southeast Community College serves three counties in the heart of the Kentucky coalfields: Harlan, Bell and Letcher. Like much of Appalachia, the region suffers from the loss of mining employment, little business development and weak public schools with a low college attendance rate. A small group that has held control for years dominates local politics. The team decided to tackle these problems head-on with projects to (1) make more capital available for new business development, (2) help disadvantaged young people attend college, and (3) broaden the base of community leadership through leadership development programmes.

Southeast's work on business development finance illustrates how the college–community team provided the determination, the innovative ideas and the right mix of leadership to make things happen. The team began by holding a day-long community workshop where business and civic leaders discussed barriers to small business development in their counties and learned about development finance models from around the country. After the workshop, team member Ken Thomas, president of Harlan National Bank, and RCCI coordinator Paul Pratt talked with local banks about creating a community development corporation. Five banks signed on to form the Pine Mountain Community Development Corporation (CDC), creating a $105,000 loan fund for small businesses that could not qualify for conventional loans. The college provided a staff person (Paul Pratt) to screen loan applicants and provide technical assistance to borrowers.

The initial fund was lent out within a year, indicating a high unmet demand for microloans in the region. Building on the experience of the Pine Mountain CDC and with encouragement from the RCCI coach and team, Paul Pratt approached the numerous loan funds that serve eastern Kentucky and urged them to pay more attention to the southeastern corner of the state, an area that has been largely ignored. After two years, these conversations led to the creation of the Appalachian Development Alliance, eight development funds that will pool resources and access new sources of public and private capital for business development throughout eastern Kentucky.

Most importantly, that area of Kentucky is able to generate more income for the people who live there, as the college works to provide appropriate skills to individuals who had never thought they could finish high school, much less take college classes. By focusing on the assets of the local people rather than their deficiencies, new investments in the area began to pay off.

Source: Sarah Rubin. 2001. Rural Colleges as Catalysts for Community Change: The RCCI Experience. *Rural America* 16(2): 12–19. Also available online: http://www.ers.usda.gov/publications/ruralamerica/ra162/ra162d.pdf; accessed 16 April 2003.

government grants or finding a private investor. The consultant and the local leaders would determine the method of funding, and the site would be chosen based on objective criteria determined by experts in golf course construction. The success or failure of the project would be judged on the presence or absence of a golf course at the end of a prescribed period. The combination administrator–golf pro would be chosen on technical criteria. If a capable administrator was found, the project would continue. However, if the club pro proved inefficient or dishonest, it would be up to the town leaders (if publicly owned) or the board of directors (if privately owned), not to users of the golf course or its employees, to correct the situation. Limited oversight could then lead to limited success.

It is assumed in this approach that answers to community problems can be reached scientifically. The problems themselves are phrased in technical terms that require expert advice regarding choices among a variety of technically feasible options. This approach requires that local residents, if they desire to participate in decisions, assimilate and absorb a great deal of information concerning complex legal and scientific issues. This greatly decreases motivation to participate. A common response is to assume that there is only one technically appropriate choice and that the experts should thus be left alone to make it.

Another assumption of the technical assistance approach is that development should be evaluated based on the achievement of predetermined measurable goals. Not only is the achievement of the goal important, but so is the efficiency with which it is achieved. Cost–benefit analysis, a technical tool developed by economists to determine the ratio of costs to benefits to the public of projects, is a particularly appropriate tool for a technical assistance approach. Local citizens are defined as consumers of development, not participants in it.

Government bureaucracies are the most frequent employers of the technical assistance approach. This approach often works to the advantage of the power structure because of its agenda-setting ability. The power structure is frequently able to prevent a particular problem from reaching the level of public discussion or, in other cases, to prevent certain technically feasible solutions to a publicly defined problem from being considered as a realistic option.

An illustration of how politics and the technical assistance approach relate to one another is in industrial recruitment. Successful growth machines are able to define industrial recruitment as an essential economic development objective, especially in communities experiencing a loss of services or population. This is done by identifying industrial recruitment as the only technically feasible alternative for generating new employment through influential organizations such as the city's chamber of commerce or community development office. It may in fact be true, for example, that in a declining community where the elderly make up a high proportion of the population, transfer payments (including such things as Social Security, Medicare and Medicaid payments, as well as private pensions and health insurance payments) are a large portion of community income. A programme for the development of locally owned services used by retirees would keep that money circulating in the community and could perhaps generate more employment and greater employment stability and income than would a potential new factory. But in most cases, industrial recruitment wins out because the elderly income multiplier does not even get on the agenda. Furthermore, companies considering a move do not want it public until the decision is final. They also prefer to deal with a single person who represents the entire community. Both of these facts militate against broad community participation in efforts to recruit industry.

The conflict approach

A *conflict model* is similar to a self-help approach in that it brings people together to articulate their needs and problems, to develop indigenous leadership and to help organize viable action groups (Christenson, 1989, p37). It is different from a self-help approach in that it seeks to redistribute power. A major organizing tool is the confrontation of those seen blocking the agreed-upon solution to the problem. Using a conflict approach, a group of local people outside the local power structure would come together to discuss their problems and needs, which could include recreation and job creation. For example, as a golf course project was put forward by the elite of the town, the group seeking empowerment would mount a counter-proposal – a local swimming pool – that would also create jobs and would in addition provide recreation for the young people and poorer members of the community who could not afford golf clubs or lessons. Instead of either calling in outside experts or working in an informal fashion with local elites to mobilize local resources, the conflict-oriented group would identify a potential site and then approach the city council and the local landowner with the demand that the land be donated or purchased. The organizer would focus on building strong groups to make these demands, stressing as an important issue the lack of recreational facilities, particularly for the less-well-to-do members of the community who could not drive to other communities. Emphasis would be on the responsibility of those with power within the community – the city council and local landowners – to act responsibly in response to the needs of the community. In another conflict model scenario, once the golf course was established, the group would demand access to the course for youth, minorities and the elderly, with subsidized transportation and public equipment, so that the principle of community-wide access to collective resources would be enforced.

The conflict approach to community development has urban origins. The approach was codified by Saul Alinsky, who began as a community organizer in

Chicago in the 1930s in a Polish neighbourhood known as Back of the Yards. By working with the residents in the working-class community to identify their grievances, the organizers helped them make specific demands of the city government. This methodology has been expanded to black organizing in Chicago, Illinois; Rochester, New York; Boston, Massachusetts; Kansas City, Kansas; and Kansas City, Missouri. It has been the basis of organization of the United Farm Workers, since Cesar Chavez had trained with Alinsky's group. The Association of Community Organizations for Reform Now (ACORN), founded by Wade Rathke in 1970 based on Alinsky's organizing principles, has worked hard to implement and refine the conflict methodology. Many community organizers around the country continue to use and modify the approach, including the Land Stewardship Project that organizes farmers in Minnesota and the Industrial Areas Foundation in the colonias along the Mexican border.

Alinsky says that the world and hence any community is 'an arena of power politics moved primarily by perceived immediate self-interests' (1971, p12). Whereas the technical assistance approach views the existing power structure as having the interests of the community at heart, the conflict approach is deeply suspicious of those who have formal community power.

The conflict approach assumes that power is never given away; it always has to be taken: 'Change means movement. Movement means friction' (Alinsky 1971, p21). And friction causes heat. The goal of a conflict approach is to build a people's organization to allow those without power to gain it through direct action. Since organizations of the powerless do not have access to significant monetary resources, they must rely on their numbers. Their numerical strength is only realized through organizational strength.

Such organizations must be democratic and participatory. Alinsky believed that downtrodden people (whom he called the Have Nots, as opposed to the wealthy Haves and the Have Some, Want Mores, the middle class) acquire dignity through participation. Experiencing denial of participation is central to their being Have Nots. He saw democracy and participation instrumentally: as means, not ends. The overall ends of community organizing should be such things as equality, justice or freedom. But in an open society like that of the US, undemocratic organization by the Have Nots can negate those ends. He also placed emphasis on the learning process. Organizing should be accompanied by a conscious effort to broaden horizons. Such education then helps prevent the Have Nots, once they become Have Some, Want Mores, from acting in their immediate narrow self-interest.

Generating Community Change

Now that the basic assumptions and characteristics of each approach have been discussed, we turn to how the three approaches are implemented.

Self-help approach

The self-help approach can be implemented in many ways. One of the most common set of steps of implementation, stressed by such existing community development entities as cooperative extension services, is the social action process. The approach involves a number of steps – *visioning*, determining desired future conditions and long-term goals, using broad-based participation, determining the assets in the community, analysing alternative ways of using those assets to move toward the collective vision, choosing specific projects that move the community toward the desired future, generating community-wide commitment, planning the implementation phase, actually implementing the plan and finally evaluating. This process focuses on social capital and generally does not address political and cultural capitals. Thus, this approach often places heavy reliance on agenda setting by the existing power structure: the power structure has veto power over any proposal brought to it by the initiators.

Recognizing the cozy relationship with traditional community leaders, which this approach represents, and seeing the need for more rapid change as resource-based communities experience serious problems of out-migration, unemployment and decline of services, cooperative extension approaches have been modified so as to incorporate broad community participation in the problem-identification phase rather than waiting until the 'organizing to sell' phase. Strategic planning methodologies, *futuring* exercises, whereby a representative group from a community is asked to establish priorities based on a strategic plan and the community's mission, and 'empowerment' approaches all involve either a careful selection of representatives from a broad spectrum of organizations and occupations or an open town meeting approach to problem selection.

Technical assistance approach

In the pure technical assistance approach, a local entity, either a local government or a private entity such as a chamber of commerce, calls upon an outside expert either to develop and assess the effectiveness and efficiency of alternative solutions to a particular problem or to design the most efficient way to perform a certain task, that is, to implement a predetermined solution to a predetermined problem. In the latter instance, which represents the vast majority of technical assistance consultancies, the expert does not question the task assigned or how it was determined that the particular problem was important. The expert merely develops a plan to implement the solution.

At times, local experts, such as planners, can deliver technical assistance. They generally receive their orders from local or regional governmental officials and are involved in defining how to perform a particular task efficiently. Defining what the task should be is reserved for the politicians. Mark Lapping, Thomas Daniel and John Keller outline the steps planners should undertake for effective economic development. In the technical assistance approach, an individual with technical competence is called upon to complete each step in the process. Clearly, these steps can also contribute to the self-help approach, depending on who decides what organization or person carries out each step.

1 Gather information and data.
2 Identify the problem.
3 Analyse the problem.
4 Develop goals and objectives.
5 Identify alternative solutions.
6 Select a solution.
7 Implement the solution.
8 Enforce the plan.
9 Monitor the effort and give feedback.
10 Readjust the solution (from Lapping et al, 1989).

Conflict approach

Because of the control exercised by the existing power structure, an outside organizer going into the community generally catalyses the conflict approach. The following steps are generally followed to build a permanent, multi-issue community organization to achieve its local members' interests and link with other like-minded groups across the state and nation:

1 Community entry by outside organizer, usually at the request of local group wanting change
    1 Appraise the local leadership, looking at both formal and informal institutions in the community.
    2 Analyse the community power structure. Who has power and what are their vulnerabilities and strengths?
    3 Analyse the situation and the territory. In particular, what seem to the major objective problems, what conflicts would attempts at solution lead to and which conflicts are winnable?
2 Building a people's organization
    1 Stimulate those outside the power structure to voice their grievances. The creation of an organizing committee of community leaders and canvassing residents in their homes are both effective.
    2 Synthesize the grievances into a statement of the problem. An effective strategy for this has been neighbourhood house meetings. For the conflict approach to be effective, it must concentrate on a single issue at a time, although the organization cannot be a single-issue organization. Crucial in this process is that the issue picked for the organization to focus on be winnable.
    3 Link the problem to organizations – working with existing organizations of the disenfranchised, creating new ones and forming alliances with

potential sympathizers. The organizing process must provide opportunities to express anger and overcome fear.

3 Engage in direct action
   1 Demonstrate the value of the power of a large number of people working together to makes gains from the traditional power structure through direct action. In particular, to retain legitimacy, people's organizations need to produce a stable supply of what public administration expert Sherry Arnstein terms 'deliverables': wins that are quickly achieved and yield visible benefits wrested from political and economic institutions.
4 Formalize the people's organization
   1 Develop a permanent organizational structure, with dues and a structure that involves members in policy, financing and achievement of group goals and community improvements.

In rural areas, particularly in the Midwest, where conflict with one's neighbours is viewed as disruptive and unmannerly, the most effective use of conflict organizations appears to be in mobilizing against the outside, particularly in efforts to stop nuclear waste dumps, power lines, school consolidation, polluting industries and the like.

An example of such an organization is Save Our Cumberland Mountains (SOCM, pronounced 'sock 'em'). SOCM was established in 1972 as a dues-paying, membership-based group that employs professional organizers. The organization is centred in the Cumberland Plateau region of eastern Tennessee and in 2002 had a membership of 2000 individuals in chapters that are county or community based.

The SOCM chapter is the primary political unit of the organization. It is a non-profit Tennessee grassroots citizen's organization working on a local level for environmental, social and economic justice in areas such as forestry, strip mining, toxic issues, tax reform and dismantling racism. The various chapter groups send representatives to the larger SOCM Board or to various issue-driven steering committees, such as the legislative committee, which largely lobbies state legislators in Nashville. The SOCM Board and the various committees hold a great deal of power in the SOCM organization and plan many of the groups political activities. In order to qualify for staff assistance, the chapter groups have to show that they have been actively working on an issue that they have identified themselves, in response to some problem originating in their local community. The staff organizer works as a 'coach' for the local 'teams'. SOCM's recent successes include winning a ten-year battle to protect Fall Creek Falls State Park from devastation from acidic mine drainage by designating 61,000 acres as lands unsuitable for mining; they have also hosted their first workshop 'in house' to combat racism.

The Kentuckians for the Commonwealth (KFTC), an organization with a similar organizational structure, succeeded after many battles in stopping the strip mining of land without allowing the surface owner any rights or say in the matter, a practice springing from the *broadform mineral deed*, whereby land purchasers in the early 1900s were able to buy up hundreds of thousands of acres of mineral rights. KFTC was instrumental in getting legislation approved to set up Universal Service Funds as well as in getting the land around the historic Pine Mountain Settlement school declared off-limits to strip mining. In 2001, KFTC had its 20th anniversary.

All of these instances involved confronting an outside public or private entity in order to stop a project or policy deemed detrimental to the inhabitants of the local community. Organizers from outside the local community and support from the parent organization are important elements in the local chapter's success against such outside forces.

Factors in Effective Change

We will now examine two important factors in all three models in community development – linkages with the outside and the planning process – to see differences and similarities among the models.

Linkages for community change

None of the models of community development that we have presented deny the need to obtain outside resources in order for community development to take place. In the technical assistance and the conflict approaches, an outside person or group of people are central to the process. In both cases, an objective of the effort is often to obtain resources from the outside. The self-help approach would appear to be one that emphasizes reliance on local resources. However, as will be seen, the ability to mobilize local resources is often a proof to those who control outside resources that the self-help effort is serious. Thus, there is a complementarity between mobilizing local resources and the ability to obtain resources from outside the community. Creating strategic partnerships is necessary in all cases (Blakely and Bradshaw, 2002). This is particularly true under conditions of very limited outside resources because those who control such resources are especially keen to ensure that their funds are well spent. What better place to spend them than on a project that has shown it can obtain resources?

Financial capital from the outside is becoming more and more scarce as both federal and state governments deal with mammoth deficits by cutting funding for social programmes, including those that benefit rural communities. As the endowments of most foundations have declined with the stock market, so have possibilities of grants from both private and public sources have declined. There are a variety of state and regional venture capital funds being started by both private- and public-sector groups, which can be an important input into community development.

However, these linkages to the outside through investment can be risky in terms of the collective agency of a community. There is an old saying: 'He who pays the piper calls the tune.' This means that the source of funding, whether the federal government or a multinational corporation, can impose a large number of conditions on the delivery of capital resources. Sometimes those conditions actually cost the community more than they gain. For example, a number of studies have shown that the tax abatements, infrastructure construction and other financial incentives poured into attracting industry in the 1980s did not even pay back the local public investment, much less create wealth in the local community.

Another important type of outside linkage is less hierarchical and therefore less risky in terms of loss of collective agency: more and more communities are forming horizontal linkages with other communities that have faced and dealt with similar problems of their own. This type of lateral learning by community groups tends to foster rather than impede collective agency. Community groups analyse their own situation and consider alternative ways to confront it. Often a community member knows of another community that has faced a similar problem. Citizen-to-citizen exchanges take place as the group that has tried a solution explains both the process and the outcome to the other community.

For example, when Lexington, Nebraska, became the site of a large IBP meatpacking plant, it met with community leaders from Denison, Iowa, where IBP began as Iowa Beef Packers, and from Garden City, Kansas, where IBP's largest processing plant is located, to learn of the problems and discuss potential solutions. As part of the general move to consolidation in the food industry, IBP was purchased by Tyson Foods, Inc., in 2001. Because the communities already had links, they were better able to work together to understand the implications of the change in ownership. The acquisition by communities of information relevant to their needs through lateral learning and technical assistance can strengthen their ability to maintain collective agency when they enter into joint ventures or other means of obtaining capital from the outside in order to improve their own quality of life.

Planning as part of the change process

Increasingly, communities are recognizing that planning is a key part of development. Planning may serve any of the types of community development, but the approach to planning differs significantly according to the model of community development being pursued.

Planning is an integral part of the technical assistance model of community development. Under this model, the primary concern is with the final product, the plan, which can then be used as a map that displays the explicit tasks that must be performed. Professional planners charged with developing community planning documents may consult with the community when necessary either by talking to designated leaders, conducting surveys, or presenting results to community meetings. Community members are involved in the process not as active participants in the decision making process but as passive providers of information on which such decisions are made.

Planners then develop an overall strategy and plan of action. The plan usually consists of a baseline projection, a projection of the desired level of economic activity, and a description of ways of bringing the two projections closer together.

Once written, the plan and its implementing components can then be used to prioritize activities and eliminate options or tasks that are not included in it. In such circumstances, the plan can be used to reinforce the notion of calling on technical rather than political solutions to problems. For example, if the plan calls for a golf course, under the technical assistance model there is little need to get broad community input into the series of decisions that goes into its construction and operation.

The increasing complexity of the decisions communities are forced to make gives a great deal of power to the city engineers or administrators who are closest to the source of technical information. Their clear expertise in understanding the arcane language of, for example, zoning and taxing alternatives aids this process. Just as the city or county attorney in the past was able to dismiss a call for change by saying the proposed change was not legal (and thus forcing the person or group who wanted change to hire their own lawyer to get an alternate opinion, which they then had to take to a higher authority), now the city engineer can dismiss any change in community resource management by saying, 'It doesn't fit the plan.' At this point, the conflict model of community development becomes appropriate, for groups may mobilize to seek other experts to support an alternative action. But most often, the first 'technical' judgement goes unquestioned.

Practitioners of self-help community development favour a different version of the planning process. When conducted in a highly participatory way, planning not only allows for development of a collective vision of community but also provides mutually agreed upon signposts to help achieve it. For example, the commitment and incorporation phases of the social action approach are, respectively, the goal-setting and implementation-design phases of that planning process. But, unlike in the technical assistance model, they are imbedded within a participatory approach. Community members who participate in the social action or similar processes have some role in shaping the goals and means of implementing those goals (although as was discussed earlier, community opinion leaders may have already channelled the social action process towards certain problems and away from others). In most participatory approaches that use the self-help model, there is broad participation in determining the basic questions to be asked. The downside of the self-help approach to planning is that it is clearly more time-consuming than is the technical assistance approach.

The conflict model of community development involves a very different view of planning. Since, by definition, the conflict model is used by those who do not have power, the relationship between goals and means is less obvious than in either of the other two models. The tactical plan for implementation of goals is heavily dependent on the response of the powerful opposition to the prior actions of the group practising the conflict approach. Tactics may change from day to day. Alinsky emphasized the importance of the element of surprise in responding to those who are in power. This need for flexibility, quick response and surprise, coupled with the fact that initially the community organizer (who is usually from the outside) must be a catalyst for building an organization, are tendencies that militate toward a narrowing of decision making to a small group of people or sometimes to a single leader. However, the long-term survival and effectiveness of the organization in achieving its goals depend on broad and deep support from within the disadvantaged group. That support is best maintained through broad and active participation. So long as the organization commands few resources, participation, if not democratic decision making, is central to maintaining support for the organization. Numbers are a substitute for financial resources. Thus, there is a permanent tension in the organization or movement between democracy and centralization of control. As the organization becomes more successful in gaining resources, participation and democracy may decline unless democratic decision making processes were explicitly attended to in the organizational phase. Thus, in addition to goal setting, the strategy for organizing is a central part of the planning process for a group using the conflict approach.

Models of Economic Development

Different people have different ideas as to what is entailed by economic development. Some see economic development as identical with an increase in community income. Others view it in terms of an expansion in the number of jobs. Still others would say that economic development involves an increase in population. The relationship between community development and economic development depends on the kind of economic development that is pursued. There are a number of models for how economic development takes place. The model that members of a community adhere to influences the kind of action they undertake to bring about change. In short, there is a relationship between the kind of economic development model pursued and the kind of community development model pursued.

The firm recruitment model

One model of economic development is the firm recruitment model. It assumes that private-sector firms have considerable geographic mobility as they seek more-favourable locations. Early tactics aimed at firm recruitment during the growth years of the 1950s through the 1970s were very straightforward, involving such things as the construction of industrial sites and proactive industrial recruiting by more sophisticated cities. It was assumed that any particular locality had a series of advantages to offer and that firms would somehow find them, although by the

1970s it had become clear that despite the favourable climate for domestic industrial growth, a community had to develop a sophisticated approach to firm recruitment if it was to be successful. Planners and social scientists carried out studies to see where firms located and what they looked for when they chose new sites.

By the economic downturn of the 1980s, states and localities had begun to realize that only a few firms moved each year and that those that did usually went overseas for cheaper labour and laxer pollution controls. Competition for the few firms serious about relocating in the US became intense. States began instituting a wide variety of inducements for firms, including grants, loans, loan guarantees, tax incentives, targeted industrial revenue bond financing, tax increment financing and state enterprise zones. When one state or locality offered an incentive, others felt obliged to do so.

Less publicized but also prevalent during the 1980s were changes on the state and federal levels that weakened organized labour. Communities used low wages as a bargaining chip in attracting firms. In fact, in a number of high-growth areas where public infrastructural investments and favourable tax structures attracted industries, the jobs that were generated paid so poorly and the working conditions were so bad that immigrant workers had to be recruited to fill them. Meatpacking plants in Kansas and Nebraska are examples of this kind of industrial recruitment. Political scientist Peter Eisenger refers to these attempts to locally reduce the cost of land, labour, capital, infrastructure and taxes as 'supply side development'.

The firm recruitment model of economic development is most compatible with the technical assistance approach to community development. Local governments would hire economic development professionals to obtain grants for built capital, to develop local tax incentive packages and to recruit new firms. These activities required little grassroots participation. In fact, they are antithetical to broad-based community involvement. Getting grants requires technical knowledge of bureaucracies and procedures. Negotiations with firms that might move to the community are best carried out in secret. The firms insist on such secrecy so that communities competing for their branch plants can be played off against each other and so that their present workforce can be kept in the dark about the potential move. Firms considering a move prefer to deal with only one person who can speak for the entire community. Such approaches discourage broad community participation.

The self-development model

In contrast to this model of economic development is what Eisenger refers to as a 'demand-oriented' approach to economic development. These include the search for new markets and new products to fit those markets. Instead of simply offering incentives to any firm willing to move, public–private partnerships are formed that help determine what firms will be underwritten by the public as those with the most potential for success – and positive community impact.

One type of demand-side approach that has been effective in rural communities is the *self-development model* of economic development. This involves public-sector groups, usually a city or county government, working with private-sector groups of individuals within a community to establish a locally controlled enterprise. A national inventory of self-development projects by rural sociologists Jan Flora, Gary Green, Frederick Schmidt and Cornelia Flora identified a number of different types of self-development efforts and mechanisms through which they worked. Key to each of them was local investment of time and capital, coupled with a sound management structure and good links to outside resources of both capital and information. Although the short-term impact on the number of jobs created may not be as great as attracting a branch plant of a major multinational corporation, communities involved in self-development have found that the risk is lower and the gains more consistent than even successful industrial recruitment. Furthermore, self-development communities were more successful in attracting branch plants than were non-self-development communities. The choice to emphasize self-development did not preclude firm recruitment, although it did make the communities less likely to offer extreme tax benefits or public investments in infrastructure.

Self-development involves sustained local economic development activities. It encourages broad-based participation, involving newcomers, women and minorities. It depends on and encourages the development of community organizations. Self-development contributes to community development and it tends to encourage participation. It gives community members a feeling of control over the economic life of their communities. In short, it promotes collective agency. It is most consistent with the self-help form of community development although it can be compatible with the conflict approach.

Successful self-development models reorganize and mobilize local assets (Kretzmann and McKnight, 1993; Green and Haines, 2002; Feikema et al, 1997). Local communities and organizations that conduct asset-mapping exercises realize the power of local assets as a mobilizing tool to bring people together, as illustrated in Box 18.2.

Asset mapping is a process of discovery, of learning what is there. If carried out properly, this process will result in new patterns of interaction among community members. Discovery is most effective when it revolves around an issue.

Mapping assets, however, is not enough. There has to be commitment on the part of local people to figure out ways of recombining the assets to address the issue under discussion. The Heartland Center for Leadership Development, the Nebraska Community Foundation and the Nebraska Cooperative Extension have been engaged in important issue-oriented asset mapping as a basis for community action.

Asset mapping is important because it allows communities to move beyond a victim mentality and recognize that by working together locally, changes can be made. It means putting faith in local people to evolve a people's programme (Alinsky, 1946, p56). Asset mapping works best when communities begin by addressing pieces of issues that can be quickly alleviated. However, early success should be a learning experience on addressing the more complex aspects of the issue, such as

Box 18.2 *Holistic self-development*

In Blue Mound, Illinois, the notion of team effort is well understood. In the early 1980s, leaders in the community realized that they had to make some changes in order to better their economy. This would require extensive planning to implement all of the recommendations made for improving the community, which most towns would find difficult, if not impossible. In Blue Mound, the townspeople believed that revitalizing the town did not have to depend on financial assistance; it could be accomplished through cooperation and hard work.

In many small towns around the country, Main Street has deteriorated and in some cases disappeared. If Blue Mound did not make significant strides to bring new business into town, they would be facing a loss of their downtown. Leaders in Blue Mound soon realized that financial assistance would have to come from local residents; they could not rely on state and federal governments. Local leaders came together and devised a plan of action, sending out more than 60 letters to residents and businesses in the community to invite them to a town meeting to discuss the issues. Representatives from a local community college were also invited to participate in the discussion, which proved to be advantageous because the college had just started working with the University of Illinois–Champaign-Urbana on ways to help small communities improve their local economies.

The town meeting proved successful, and it led to several other meetings with the University of Illinois, which became interested in the project of revitalizing Blue Mound. The university provided a team of graduate students to help the village create a development programme that would extend through the year 2000. The village invested $1500, and the university absorbed the other costs. By 1983, the Blue Mound Development Corporation (BMDC) had been formed as part of the comprehensive plan that the university had designed for the community. A vision statement was formed, and numerous recommendations were laid out for the town to follow, including 'designing appropriate land use ordinances, expanding public services, improving local business and economic climate, upgrading the appearance of the downtown, improving housing and social services and strengthening the village financial condition' (Kline, 2000, p92). This farming community was able to support retail businesses and new housing, and the residents agreed that they needed to improve these elements of the town in order to attract new people to the community.

The BMDC, made up of seven people, had an annual budget of less than $1000; however, their vision did not include using money for community development. They wanted to invest people into the project so that all of the residents were part of the town's progress, and it worked. Some of their early attempts to improve businesses in the community backfired; for example, they helped the local metal-making company expand, but after it did, it moved to a bigger city. However, most ventures were a success. The local newspaper relocated to a new, larger building on Main Street after changing ownership in 1986, and after renovating its space, it had room for other businesses to move into the building. A barbershop, an attorney's office, and a golf pro shop moved into the extra space and set up their businesses. Soon after, several other businesses began moving into the downtown area, including entrepreneurs in the area.

Then BMDC began working on filling a void in the community. The residents wanted a dentist; they had had a physician in town for more than 30 years but no dentist. The board already had a connection with the University of Illinois, which made the search for a dentist a bit easier. The board knew they had to make the town look attractive and inviting to a newly graduated dentist. A young dentist who expressed interest in the town was invited to Blue Mound; the BMDC sponsored a potluck dinner, and members of the school district, local business owners, church representatives and local residents met him and invited him to come to their community. The dentist responded well to the invitation and decided to move to Blue Mound. The community wanted to help him set up his practice, and since the BMDC did not offer financial assistance, people volunteered to help. A local carpenter, plumber, electrician and other residents donated their time and skill instead of money. The dentist had a new practice in a refurbished building, and Blue Mound had completed another successful project.

Soon after the dentist moved into town, Blue Mound received a devastating blow. The local grocery store burned down, and the grocer decided to retire and not rebuild. The BMDC had to find a replacement, but none of the big grocery chains wanted to move into the small town. It became evident to the board that they would have to build the grocery store themselves, and after selling shares to local residents and leveraging those funds with a loan from a local lender, they opened the Blue Mound Store Corporation (BMSC) and hired an experienced grocer to run the business. The BMSC did so well that by the late 1990s, it had begun paying dividends to its community stockholders.

The community had several other accomplishments throughout the 1990s, including a plan for constructing senior housing, upgrading the village's water delivery system and forming a police department, which now employs a full-time police chief, two part-time officers and five auxiliary policemen. The Blue Mound police department, even though it is in a rural community, has become a state-of-the-art department and was featured in a 1992 issue of *Law and Order* magazine as a model for developing a programme entitled Dial-a-Cop. This system allows people to reach a police officer even when no one is at the station. Most of the improvement and development in the police department came from grants and resident volunteers. Because of the successful new police department, the town is now able to promote their community as being a 'safe and secure' environment, which helps attract new residents.

Blue Mound's success by the year 1998 was astounding, and it had come from a holistic effort to improve the community's economy. The key ingredients for success in Blue Mound were leadership, community support and involvement, sound planning, organization and a sense of accomplishment. Forming connections among many diverse groups of people, working toward common goals and seeing tangible results from planning efforts were all key components for successful community and economic development in Blue Mound.

Source: Steven Kline. 2000. Community Leadership and Vision Pay Off for Blue Mound, Illinois. In *Small Town and Rural Economic Development: A Case Studies Approach*, ed. Peter V. Shaeffer and Scott Loveridge, pp88–98. Praeger: Westport, CT.

unequal power within the community or long-term disinvestment in the community by public and private sectors.

Focusing on assets does not mean that a community is unaware of the impact of major social forces, including economic concentration, increasing competition, and changes in government programmes. Some see an *asset-based approach* as ignoring such issues. Although this can happen, mobilizing local resources in new ways is more likely to create a climate for successfully addressing more difficult structural issues by strengthening local social capital.

Do Communities Act?

Sociologists have long asked, ‘Do communities act?’ (Tilly, 1973). How much that happens in a community is determined by the outside and how much by the inside? Sociological research has begun to identify which communities act and under what circumstances (Logan and Molotch, 1987). These authors argue that more and more action for social change is occurring not where people work but where they live.

Summary

Community development is what people do to improve the overall quality of life in the community. Although community development often involves economic development, it implies far more. Central to the concept of community development is the concept of collective agency. Collective agency is the ability of a group of people to solve common problems together.

Contrasting three models of community development illustrates dramatically different approaches to community change. The self-help model focuses on the process by which people work together to arrive at group decisions and take action. It assumes that communities are homogeneous and consensus based. The technical assistance model focuses on the task to be accomplished and uses outside expertise to help community members accomplish that task. This model assumes that answers can be arrived at objectively, using the scientific method. The conflict model focuses on the redistribution of power among community members. It assumes that power is never given but must be taken away. Each model gives rise to a different community development strategy.

Two factors are important to all three models of community development. The first is linkages. Communities need linkages to outside sources of information. These linkages can be with external agencies or they can be with other communities, enabling lateral learning to occur. The second factor is planning. Planning is a key part of development but will be approached differently depending on the model of community development being followed.

Economic development is one part of community development. Consequently, the type of economic development strategy pursued should match the community development model used. Two of the more common models are the firm recruitment model and the self-development model. For both community development and economic development, new collaborations must be formed inside and outside communities.

Appendix: Key Terms

An *asset-based approach* to development is used by most community developers now, in contrast to the old *needs assessments*. Whereas a needs assessment focused on what was not in a community and developed a wish list of projects and programmes, an asset-based approach links the various capitals existing in a community to see how they can be recombined to achieve a desired future condition.

The *broadform mineral deed* was used by land purchasers in the early 1900s to buy up hundreds of thousands of acres of mineral rights, leaving subsequent surface owners legally helpless to prevent destruction of their homes, yards and gardens by strip mining when this technology came into vogue in the middle of the century.

Collective agency is the ability of a group of people to solve common problems together.

Community development is what people do to improve the overall quality of the community.

The *conflict model* of community development focuses on the redistribution of power among community members.

The *firm recruitment model* of economic development assumes that private-sector firms have considerable geographic mobility and seeks to engage community resources to attract those industries to the community.

Futuring is a process used by community developers and planners that brings together a small but representative group to assess the current environment, develop a strategic positioning plan and establish priorities based on the assessment and consistent with the plan and the organization's or community's mission.

The *self-development model* of economic development uses public-sector groups working with private-sector groups to establish locally owned enterprises.

The *self-help model* of community development focuses on the process by which people work together to arrive at group decisions and take action.

The *technical assistance model* of community development focuses on the task to be accomplished and uses outside expertise to help community members accomplish that task.

Visioning is a process used by community developers and planners to work with a broad-based group of citizens to determine desired future conditions and long-term goals for what their community should be.

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Issues for More Sustainable Soil System Management

Norman Uphoff, Andrew S. Ball, Erick C. M. Fernandes, Hans Herren, Olivier Husson, Cheryl Palm, Jules Pretty, Nteranya Sanginga and Janice E. Thies

Assessing sustainability is more difficult than evaluating productivity because it depends on future evidence, which by definition cannot be known in the present. Certainly sustainability is an aspiration for both the first and second paradigms for soil system management. There are reasons for questioning the sustainability of Green Revolution technologies, with their heavy dependence on external inputs. Nobody can know the future prices for petroleum, which will influence the cost of energy for mechanized production and of inorganic fertilizers and many agrochemicals, but recent data give no grounds for an optimistic view of agricultural input prices. Biotechnology advances could possibly overcome the stagnation of cereal yields in most major producing countries at some time in the future, but this is uncertain.

There are no long-term or aggregate data to support any claims of sustainability for second-paradigm approaches since these are relatively new. No better claims can be made for first-paradigm agriculture. What time-series data are available on specific innovations indicate that higher yield levels with biologically based management are sustainable so long as farmers can maintain their inputs of biomass to soil systems that support and enhance levels of soil organic matter. Reduced use of inorganic fertilizers and of agrochemicals together with increased application of organic matter to the soil should have positive effects on soil biota and on associated agricultural production so long as essential nutrient levels can be sustained in soil systems. This is an empirical issue to be addressed.

1 Processes Contributing to Sustainability

As stated above and discussed below, second-paradigm approaches are not necessarily 'organic' in that they do not reject the use of inorganic inputs. Rather, there is a positive emphasis on mobilizing and managing biological processes so as to minimize the need for inorganic inputs. Yields as high or higher than those from first-paradigm practices can be attained through second-paradigm approaches, contradicting the often-assumed superiority of 'modern agricultural practices'. How sustainable alternative agricultural systems will be, and how their long-term productivity can be enhanced, are both important questions, not currently answerable.

As relatively little investment has been made in researching the alternatives to date, these questions remain to be addressed explicitly and thoroughly. Evaluations made will be more illuminating if they are undertaken not just in terms of certain hypotheses to be tested, but are linked to broader questions of how to understand soil systems and their sustainable productivity. On the basis of both research and experience, optimizing patterns and rationale for resource use should be developed and also changed over time as knowledge and feedback from practice accumulate.

It is difficult to sum up in single numbers the changes in soil systems' fertility and capabilities as these include contingent qualities such as resilience when confronted with biotic or abiotic stresses. Of particular importance for sustainable agriculture is the enhancement of soil water-holding capacity and drainage. This is very dependent on the kinds of soil biological activity that lead to better particle aggregation, creating soil that can be both better aerated and infused with water at the same time. The ability of soil systems to absorb rain run-off – to capture what Savenije (1998) has characterized as 'green water', i.e. water stored and used *in situ* – will become more and more essential in this century as variability in the timing and amount of precipitation is likely to become more extreme, which has dreadful effects on most agriculture. Acquiring and distributing 'blue water' from surface flows or groundwater reserves with all of its costs and inefficiencies in conveyance will become ever more costly. By contrast, improving soil characteristics through biological activity and management will store water, the most essential resource for agriculture, in soil horizons and root zones where it is most needed, and at lower cost.

The practices presented and evaluated in this book are recent enough that no conclusions can be firmly drawn about their sustainability. But the biological processes and effects that are being intensified or enhanced are ones that have been occurring for ages. The results of sustaining mutually productive associations between flora and fauna – specific and diverse microbial populations in the rhizosphere and in plant roots themselves – have been the production of growth-promoting hormones, beneficial meso- and macrofauna activity in the soil, biological nitrogen fixation and phosphorus solubilization, the build-up of carbon in the soil, mycorrhizal 'infection' of roots, induced systemic resistance of plants to damage by pathogens, diversified root systems in the soil that can access a larger proportion of its volume, bringing up nutrients from lower horizons of the soil to distribute on the surface and in upper layers, and reducing leaching, to list some of the most prominent.

Any one of these processes, if occurring to an extreme, can have deleterious effects, much like the overuse of inorganic fertilizer. The complexity of natural systems includes mechanisms and feedback loops for curbing excesses. Agricultural practices that fit into these flows and these mechanisms, not truncating this complexity, have better prospects for sustainability than ones that seek to set their own parameters independent of what existing systems would support. This is the challenge presented by the second paradigm.

2 Nutrients in a Soil System Context

Agricultural systems lose carbon and nutrients through the off-take of crops, but there are multiple mechanisms for restoring elements in deficit. Plants have been 'exploiting' soil resources for millions of years without depleting them because of efficient cycling and little nutrient loss. Depletion of available nutrient supplies in soil systems has been more a consequence of their management and off-take of nutrients through harvest than of natural processes.

Nutrient constraints need to be understood and remedied in terms of the supply of 'available' nutrients. Most soil systems have large stocks of nutrients in the soil that are currently 'unavailable', being bound up in recalcitrant chemical complexes or physically inaccessible. The issue for agricultural practice becomes whether rates of utilization of these 'unavailable nutrients' can meet production needs and expectations and are sustainable.

- Carbon is continuously restored to the soil through processes of photosynthesis and root exudation and through litterfall. The share of photosynthate exuded into the rhizosphere is difficult to measure and certainly varies, but plants commonly put about 10–20 per cent of the carbon they acquire from the atmosphere into the soil (Pinton et al, 2001). The amount of litterfall and crop residues returned to the system varies with system composition and management.
- Nitrogen (N) also from the atmosphere is fixed by organisms in, on and around plant roots and even on their leaves, in what is referred to as the phyllosphere, so N is restored to the soil through multiple pathways. Nitrogen is certainly abundant; the question is whether sufficient amounts in available forms can be maintained in the soil to meet crop needs, offsetting losses through leaching and denitrification as well as crop removal. Nitrogen fixation is not limited to leguminous species. Also the contributions that protozoa and nematodes make to N available in plant root zones have seldom been given the attention this process deserves.

- Phosphorus (P), often identified as a key constraint to crop production, is actually abundant in most soils, with much less than 10 per cent of the total supply 'available' at any one time. There is much potential for P solubilization and mobilization through biological processes. Turner and Haygarth (2001), in discussing their evidence that microorganisms significantly increase the P available in soil when it is alternately wetted and dried, suggest that the same mechanisms probably apply for other nutrients, but these have not been studied. It remains to be determined to what extent these processes can provide P and other nutrients at the levels and rates needed to meet crop demand and if it can be done sustainably.

There is a legitimate concern about 'where the nutrients will come from' if exogenous inputs are reduced. An ICRISAT study addressed that question and showed that organic inputs could match inorganic input-dependent practices in terms of yield, with a concomitant build-up of soil resources both chemically and biologically. A concern whether farmers can access sufficient organic resources for such production is valid but may be solvable. Relatively little scientific research and experimentation have gone into producing biomass rather than just yield. Plant breeding efforts over recent decades, aiming to maximize the Harvest Index, have sought to reduce the biomass, which can feed soil microorganisms as well as livestock. Biomass production has been raised from 6–8 t ha^{-1} to 25 t ha^{-1} in Brazil by introducing a calculated variety and sequence of plants into the system.

Significant research and experimentation have been done on N-fixing trees and on green manures and cover crops grown *in situ*. If research and extension efforts comparable with those that went into the Green Revolution were focused on the production of biomass within agricultural systems as well as on otherwise non-arable land, this nutrient and biomass constraint could, it seems likely, be alleviated creating more scope for biomass-based soil fertility management. Work would need to be done on implements such as cutting tools, shredders and equipment for transport that could raise labour productivity when handling biomass for agricultural purposes. A combination of enhanced productivity and reduced costs based on innovations that alleviate this constraint could make second-paradigm practices more profitable and would present producers with a different incentive structure in the future.

There will in most soil systems be some nutrient constraints, following von Liebig's 'law of the minimum', based on the concept that there will always be some nutritionally limiting factor operative in the soil (van der Ploeg et al, 1999). This is why the second paradigm is better characterized as 'biological' than as 'organic', since it does not reject the use of inorganic nutrient inputs.

Justus von Liebig, the first major contributor to our knowledge of soil fertility, considerably expanded his thinking by the end of his scientific career. Rather than focus on particular chemical elements in a reductionist manner, he advocated a more holistic view of soil systems and paid more attention to their living components. In 1865, reflecting on his life's work, von Liebig wrote:

> In the years 1840 to 1842, I proposed that the natural sources which deliver to plants the nitrogen they need are not sufficient for the [production] objectives of agriculture. A series of observations as well as continuous reconsideration have indicated to me, however, that this view is not correct ...
>
> For millennia, millions of people have believed, and millions believe it still, that the sun revolves around the earth because this is what they perceive. In the same way, many thousands of farmers have believed, and thousands still believe, that the practice of agriculture revolves around nitrogen, even though this belief has never been scientifically validated, and never will be scientifically supported because all progress and indeed all improvements in agriculture revolve around the soil (republished in Liebig, 1995, pp12–13; translation by Uphoff).

Von Liebig's conclusion from a lifetime of research devoted to understanding soil fertility was to emphasize the biological factors and processes within soil.

This perspective does not make chemical elements less important but rather puts them into a living context. The interactions of the components and processes of biological systems that have evolved over millennia provide a framework for comprehending and managing soil systems. This does not suggest that 'nature' cannot be improved upon. But the admonition of Leonardo da Vinci: 'Look first to Nature for the best design before invention', not only has a certain logic; a growing body of scientific evidence is explaining the merits attainable from complex relationships and biodiversity within soil systems when they are enlisted on behalf of agricultural production.

How sustainable any particular set of practices will be remains an empirical question that deserves close and continuous study. Sometimes physical interventions, such as profile modification, will enhance the soil's biological processes and capabilities. On the other hand, research has shown that one biologically oriented practice, zero-tillage, by itself is not always the best practice (Govaerts et al, 2004). Reduced tillage needs to be coupled with the use of mulch to create conditions for plant, microbial and macrofauna growth that are optimal. While these can contribute to denitrification, they contribute also N fixation. In complex systems, one seeks net positive results, as many contradictory and offsetting processes are likely to be involved. There is no reasonable basis for being opposed to 'chemical interventions' in soil systems as all of the processes discussed here involve chemicals, in various forms. While some adverse effects of certain interventions can be identified, there are at the same time various chemical interventions that can be supportive, and in many situations essential, for well-functioning agricultural soil systems.

We began this book by affirming that all soil systems have these three interactive facets – chemical, physical and biological. These are not subsystems or components, but basically coequal *dimensions* that are conjoined in time and space. Our focus and emphasis on this third facet has not tried to make it supreme but rather to restore balance to soil system analyses and prescriptions, compensating for past neglect. Everyone must recognize that there are some dynamic forces driving soil systems that come from outside, particularly climate and human interventions, while appreciating explicitly the animation of soil systems that is endogenous.

3 Some Issues for Biologically Driven Soil System Management

3.1 Optimizing the use of organic and inorganic inputs

One of the most important issues for the next decade or two as agricultural systems move toward more biologically framed management practices will be how to optimize the use of inorganic soil amendments so that there is a positive-sum effect on agricultural productivity. The principle is that of 'pump-priming', where utilizing a small amount of resources can elicit a much larger flow of desired resources. Where available soil nutrients are deficient, the practice of adding inorganic fertilizers has been conceived initially as zero-sum, compensating for a deficiency.

When inorganic nutrients are introduced into soil systems, unless sufficient organic matter is supplied to feed the soil biota and maintain levels of soil organic matter, there is often, over time, a depression of soil biotic communities and their processes that support many aspects of soil fertility. In such cases, plants in the soil become increasingly dependent on inorganic inputs, because organic inputs are diminished. A substantial amount of the nitrogen taken up by plants, by some estimates 20–40 per cent, is cycled through nematodes and other fauna that occupy middle ranks of the soil food web (Badalucco and Kuikman, 2001; Bonkowski, 2004). Much of this is forgone when inorganic amendments are made. On the other hand, there can be positive-sum dynamics when organic inputs are combined with inorganic amendments that maintain the nutrients, soil organic matter and its biological processes that underpin soil fertility.

Short-term benefits from inorganic soil amendments are common. There can also be long-term benefits such as the residual effect of phosphorus and lime applications. But the long-term productivity ensuing from such amendments should be assessed empirically rather than simply assumed. Often when soil systems have been primarily managed with inorganic nutrients (first-paradigm approaches) are switched to more biologically based systems (second-paradigm approaches), there can be a reduction in yields until the soil biological system has been redeveloped, including stocks of soil organic matter and the diversity as well as abundance of soil organisms. How to reduce the length and magnitude of such 'transitions' in agricultural systems is one of the most important and practical research questions for plant and soil scientists in the years ahead. The answers will vary, probably widely, among soil systems and for different crops. The results reported from ICRISAT are encouraging in this regard. But this remains a thoroughly empirical question. Some rough generalizations can be formulated, but actual practices need to be evaluated with both data and with sensitivity to the variability and surprises inherent in the biological realm.

3.2 Applicability to commercial agriculture

The impetus for most of the work that is reported in Part III [of *Biological Approaches to Sustainable Soil Systems*] was to identify agricultural production practices and systems that could benefit particularly the kind of impoverished, food-insecure rural households for whom Sanchez's 'second paradigm' was explicitly formulated. The needs and opportunities of these fellow citizens of the world have motivated most of the work of the editorial group throughout our lifetimes, as it has the research and practice of most of the contributors. However, what has been learned about biological approaches to enhancing soil system fertility and sustainability is similarly relevant, with appropriate modifications, to large-scale farmers practising industrialized agriculture.

High-input farming systems are of limited benefit for a majority of the world's current farmers who have low incomes and are often isolated, relating to 'the market' intermittently and seldom on very favourable terms because they lack information, bargaining power, and the essential infrastructure and institutions necessary for effective market participation. Modes of production that reduce their dependence on capital inputs and thus lower costs of production give them more opportunity to engage in market exchanges on terms that benefit them.

The vision for second-paradigm agriculture is not perpetual subsistence cultivation. Instead, it points toward various kinds of intensification that are more remunerative as well as environmentally benign, toward what Conway (1999) has dubbed 'the doubly green revolution'. Recently, UN secretary-general Kofi Annan has called for 'a uniquely African "green revolution" for the 21st century' (Annan, 2004). We expect that this will depend heavily on the kinds of innovations discussed in this book. When looking for good examples of productive new approaches for Part III [of *Biological Approaches to Sustainable Soil Systems*], it was gratifying to see that more than half of the chapters written were based entirely or in large part on work going on in Africa. This is an encouraging statistic. Moreover, for small-scale farmers the increases in profitability accompanying more biologically based production methods can be even greater than the changes in output, so the socioeconomic benefits from these methods can be more than the agronomic and environmental ones.

Larger commercial farmers are, at the same time, experiencing cost-price squeezes that are eroding the profitability even of large-scale operations. The globalization of commodity markets is making even big producers subject to the vagaries of the market. These larger producers are supported by over \$1 billion day^{-1} of governmental subsidies, meaning that taxpayers in the richer countries are encouraging and paying for these inefficiencies. They also have serious negative externalities for small-scale producers in poorer countries.

As global climatic influences become more variable and extreme, the vagaries of weather further complicate those of market forces. The more capital that farmers have invested in their operation, the more vulnerable they become to shifts that benefit consumers at the expense of producers. Cultivating robust soil systems that can better withstand the effects of drought and flooding, through better water-holding capacities and better aggregation, will become more and more relevant to commercial agriculturists, whose large capital investments and debt hold them hostage to climatic stresses.

More immediately, environmental and health considerations are likely to begin shifting current calculations as regulations constrain the timing, amounts and kind of inorganic fertilization that can be used, and the application of pesticides. Consumers' concerns about their exposure to agrochemicals and residues have made organic agriculture the fastest growing part of the agricultural sector. Worldwide demand for organic products is rising approximately 20 per cent per annum, as reported in *Nature* (22 April 2004). While scientific evidence on the health benefits of organic food products is still mixed and thus contested, the main uncertainty is over whether benefits are as great as proponents claim, with no support for the converse conclusion that food grown with synthetic inputs is better for human health than that produced 'organically'. As long as there is rising consumer demand and it is profitable to move toward sustainable agriculture practices – as some large commercial producers such as Dole and Unilever have begun to do – the appeal of more biologically based agriculture will continue to grow.

3.3 Some constraints to be addressed

Labour intensity

One limitation on many biologically based practices has been their relative labour-intensity, although some like direct seeding through permanent vegetative cover and green manures and cover crops are labour-saving from the start. Mechanized, energy-intensive agriculture was developed to enhance farm profitability by reducing labour requirements. The cost of labour is rising around the world; but so are the prices for fuel and agrochemical inputs. The low prices for petroleum that supported agricultural as well as industrial expansion in the latter part of the 20th century are probably now 'history'.

The economic logic of technical change charted by Hayami and Ruttan (1985) will sooner or later begin reflecting the greater relative scarcity of productive land and the rising costs of fossil fuel-based inputs, and their transportation, even as labour costs continue to rise. Especially in developing countries, the relative availability of labour will continue to influence factor markets.

By expanding units of production in the past, profits could be enhanced by economies of size, not just of scale. (Economies of size derive from economic advantages that are due to greater bargaining power in the market; economies of scale reflect gains from more efficient resource use.) Indeed, the productivity of land usually declines in larger-scale operations as soil systems are less carefully managed, as labour and capital are applied across larger areas.

In this century, as population continues to grow, even if the rate of growth is slowing, previous strategies that use land profligately will become less viable as the relative availability of good land per capita diminishes. Actually, if the current system of agricultural subsidies in rich countries were eliminated, this would rapidly transform the capital- and chemical-intensive nature of their agricultural production, which has been favoured by policies rather than by market-determined price structures. In the future, it will probably become economic to apply more labour to land, provided this is done productively, rather than continuing to rely on land-extensive strategies. Various methods and systems that have been documented in Part III [of *Biological Approaches to Sustainable Soil Systems*] can help with such a transition.

Some biological innovations are not necessarily more labour-intensive, e.g. soil inoculations and direct seeding with no-till. The latter saves fuel as well as the labour and other costs of plowing and weeding, which is why it is spreading in Latin America, North America, Europe and South Asia. Others methods like the System of Rice Intensification (SRI) and composting may require more labour, but to the extent that they give higher per-hour returns to labour, they are economically attractive, and with time and experience as well as mechanical innovations, their labour time is reduced.

Most of the technologies heretofore identified as labour-intensive did not offer high returns to labour. Labour has been used abundantly, even excessively where it was cheap, to make land, capital or water more productive. This necessarily diminished labour productivity. Because second-paradigm methods are mobilizing resources from the soil or atmosphere through essentially free (unpaid) biological activity, it is possible to have higher labour productivity at the same time that labour inputs are increased, i.e. with greater labour intensity. If this is a more profitable use of labour, it can become attractive to farm households and to investors even if more labour is required. The limitation will then be whether sufficient labour supply is available to take advantage of the opportunities (Moser and Barrett, 2003).

Biologically oriented methods are not necessarily limited to a small scale. SRI, for example, is being practised on a larger scale, not limited to smallholdings, now that its methods are being better understood. Good organization of cultivation practices is required, but an increased requirement for labour could benefit both the farmer and hired labourers. Actually, the SRI methodology is proving to be labour neutral or even labour-saving once farmers gain familiarity with its techniques (Anthofer, 2004; Li et al, 2005; Sinha and Talati, 2005). Whether alternative technologies will in the long run require more labour is still an open question. Not all of them will be equally dependent on more labour inputs. In any case, what is more important is whether and how much they can raise labour productivity.

Many of the innovations reported in this book as they are scaled up and as farmers, scientists and extensionists gain experience with them, will have labour-saving modifications that diminish this constraint to wider adoption. A main constraint for the spread of conservation agriculture (no-till) has been the availability of suitable implements. As the designs for tools, equipment and implements become better suited to farmers' conditions and as the production and supply of these are ramped up, with concomitant reductions in price, the acceptability and spread of biological innovations should be hastened.

Biomass

A constraint that can be critical for many of these biologically driven innovations is the availability of biomass for keeping soil energy and nutrient stocks sufficient to support higher levels of biological activity. The use of fast-growing leguminous trees and cover crops presents varied opportunities for increasing biomass and also enhancing N supplies in the soil. Finding ways and means to grow more abundant biomass on presently uncultivated land, with techniques that are environmentally benign and labour-efficient, is one of the most important areas for research in support of various biologically driven approaches. Complementing this are the production and use of bioproducts such as compost and inoculants that enhance the productivity of organic and other inputs.

As noted above, little thought and little investment have been devoted to reducing biomass production as a constraint. As long as the returns to making organic inputs are moderate to low, there is little incentive for researchers or farmers to tackle this problem. But the kind of productivity and profitability gains that are documented in Uphoff et al (2006) should make this an attractive area for experimentation, including the design and production of tools and transport equipment that can enhance labour productivity. The work of CIRAD and its partners in Brazil and Madagascar has shown, for instance, that there are some plants that can grow very well in dry or cold seasons and have aggressive rooting systems that improve soil structure. These can produce large amounts of biomass when there are no crops being grown. This means that there is little or no opportunity cost in terms of agricultural output and, instead, a substantial augmentation of production when these plants are utilized to increase soil organic matter and improve physical characteristics.

Further, as noted above, inorganic nutrients can often be productively used to increase biomass output. No opposition or mutual exclusion between organic and inorganic inputs should be erected that leads to a suboptimization that is not in the interest of farmers or of sustainable soil systems. Soil and climatic constraints have been the major physical limitations on agricultural production in the past. Inorganic inputs that help to increase organic outputs can diminish both constraints. By creating better soil conditions and root systems, they can even offset some of the constraints of rainfall and temperature by holding water and buffering heat or cold.

The production of compost on a commercial basis, and especially of vermicompost, is expanding in India and other countries. The production of biofertilizers and agents for biological control of pests and diseases is being taken down to the village level, so that employment is created at the same time that farmers using these bioproducts get higher output and profits. Unlike the production of biomass, manufacturing these products does not require any access to land. The same is true for production of bacterial or fungal inoculants, which have the effect of 'producing more land' by raising the productivity of existing cultivated area. These are innovations well suited for the 21st century. Biologically based agriculture will, it appears, be increasingly integrated into commercial production activities at both large and small scale as part of future agriculture.

Training

Because these new approaches are knowledge-intensive, and require some changing of mindset as well as having factual information, a principal constraint for their spread is a lack of understanding not just of techniques but also of rationale and principles. The practices being proposed often go against what has been taught in schools and universities for 150 years. Yet they are supported by a huge amount of research and now-spreading practice.

Training is probably too narrow a concept for what is needed, though the substance of biologically based agricultural thinking should be incorporated into training programs around the world. These new practices represent a shift in paradigm, from input-dependent, exogenously focused production systems to ones that are soil-system-based and endogenously focused. They adopt an ecological perspective that appreciates the interactions among organisms, seeking to maximize positive synergies and to control or eliminate negative effects. The expanding field of biotechnology can become compatible with this perspective if it becomes less preoccupied with manipulating the genotypes of individual species and appreciates more the interaction among species. Genes are of course important, but a genocentric view of biology is being superseded by concerns with G × E interdependence, studying genetic interactions with environment. Thus, the relearning is not just for farmers but also for scientists and extension workers.

4 New Directions for Agriculture in the 21st Century

Brazil is a country held up as a paragon of modern agriculture, with a dynamic and productive agricultural sector, expanding through many large-scale operations. Yet as seen in Uphoff et al (2006), it is also a country where some of the most interesting large-scale applications of the new, biologically based thinking about agricultural improvement can be found (Boddey et al, 2003). Brazil is a country where agriculture is not subsidized as in North America and Europe. Indeed, it faces significant disadvantages of transportation costs given its global location and the location of many of its farming areas. Still, Brazil is becoming more and more competitive in the world market.

The area under newer systems of production has now reached at least 22 million ha in Brazil, growing by 1–2 million ha yr^{-1}. Use of conservation agriculture techniques has spread even faster in the US, more than doubling between 1997 and 2003 and now covering an area 50 per cent more than in Brazil, according to Derpsch and Benites (2004). Some of the 'negative externalities' of Brazil's modern agriculture, employing a high degree of mechanization and soil tillage along with heavy inputs of mineral fertilizers and agrochemicals, are becoming too great to be ignored, with adverse impacts on soil quality and microclimates. The rising economic costs of conventional production methods are pushing Brazilian farmers to reevaluate their technical options.

Research on different approaches to soil system management is cumulating across many countries, building upon decades of basic research conducted while most investigations were still being carried out within the context of the first paradigm. It is surprising to see how many of the seminal scientific studies published on phytohormones, mycorrhizal associations and nitrogen cycling through protozoa and nematodes, to take just three examples, were done in the 1950s, 1960s and 1970s, with little attention paid to them. However, this work has persisted and matured over the past 50 years, strengthened now by new analytical techniques, many at the molecular level, giving clearer outlines and more specificity to the actors and processes in the soil food web that have been amorphous and inexact. Their consequences for plant/crop performance and for agroecosystem functioning are becoming better known.

4.1 Rationale for new directions

The factors making the second paradigm more salient and attractive are numerous, going beyond the accumulation of scientific knowledge that offers explanations for the beneficial effects observed and measured. These include the following:

- Changing factor proportions – Land per capita ratios will require raising land productivity through more intensive, i.e. less extensive, production strategies as labour supply relative to land will continue to increase. Whether labour in the agricultural sector becomes more productive will depend on the technological and institutional configurations that this century evolves. The scientific basis for enhanced land and labour productivity through intensive management of plants, soil, water and nutrients is available and growing. Especially more productive utilization of freshwater resources will become imperative in many countries and regions, making the enhancement of root growth and soil biotic communities more essential.
- Calculations of real cost are changing as environmental 'externalities' get figured into societal if not always individual assessments (Pretty et al, 2000; Pretty, 2005; Tegtmeier and Duffy, 2005). Groundwater and soil contamination from N fertilizers and agrochemicals is increasingly subject to regulation while the economic costs of their use become relatively greater. Economic and environmental considerations are favouring movement toward management strategies relying more upon intrinsic biological and ecological processes.
- The disgrace of poverty and hunger that still afflict too many people on our planet suggests that new approaches are called for in the agricultural sector, where, ironically, most of the world's hunger is still concentrated. External input-dependent technologies continue to bypass the poor. Biological technologies can be adapted to the conditions of resource-limited households and can be made to benefit producers and consumers.

The argument that synthetic external inputs are necessary to 'feed the planet' (Avery, 1995) is contradicted by the evidence presented in Uphoff et al (2006). Biologically based agriculture that combines the use of organic and inorganic inputs can match or surpass first-paradigm agriculture. It should be possible to produce more surpluses to meet the food needs of the urban poor with more intensive methods given their demonstrated potentials.

Also, the lower costs of production with these methods can make them more profitable for the poor and also reduce risks of loss when less capital investment is required. This was seen in an evaluation by IWMI-India of SRI adoption by impoverished farmers in West Bengal. Even with only partial use of the recommended methods, yields for 110 farmers using both methods were 32 per cent higher on their SRI plots, while their net profits ha^{-1} were 67 per cent higher because costs of production were lower (Sinha and Talati, 2005). Concerns with poverty reduction and food security add to the rationale for taking the second paradigm seriously.

4.2 Paradigm change

As stated at the outset of the chapter, we do not expect one paradigm to replace the other. That is not how the history of interaction between ideas and practice has occurred. However, as new paradigms gain credence and influence based on accumulating evidence in their favour, eventually new combinations of practice emerge that suit both the ideas and the objective conditions as well as the needs of those people who are engaged in the application of available knowledge. The second paradigm is still in its early stages of development, although it is now much more fleshed out and robust than when it was proposed ten years ago.

There is need for continuing and expanded research to validate and vary the principles and conclusions upon which it is based. But this is not a case where science will first create new opportunities, and then technological applications will be derived from the emergent knowledge. Much of the knowledge base for the second paradigm has been emerging from practice, with scientists then investigating the new ideas and opportunities with their standard methods of analysis. A two-track rather than a sequential approach is indicated for this domain, as there is already enough evidence and scientific justification for application and refinement of second-paradigm thinking, supported by government extension services, NGOs and farmer organizations. Concurrently, researchers have a huge and promising research agenda before them framed by the second paradigm. Pursuing the questions it raises should give higher returns to research investments at the margin than continuing with more thoroughly investigated questions deriving from the first paradigm.

4.3 Knowledge-driven change

Uphoff et al (2006) was written for researchers who have a direct interest in practice and for practitioners who appreciate the fruits of research. We have tried to meet high academic and scientific standards, but the motivating concern was to produce and share knowledge of practical value. The contributions have been intended to speak to the interests and needs of persons who are seeking to get most, and most sustainable, benefits from the resources available to the agricultural sector and for the producers within it, including particularly the most resource-limited ones.

More productive and sustainable strategies will derive from a thorough knowledge and appreciation of the biological nature of soil systems. These are shaped by physical characteristics, and their transactions are made in the coin of chemistry. But the fundamental determinants of fertility remain the soil biota that have coevolved symbiotically with plant root systems and with plant shoots and animals above ground for 400 million years.

This reality can be overlooked but it cannot be repealed. It can be compensated for, if undercut, by use of external inputs. Such a strategy can be and often has been successful, and it will continue to be beneficial in many places for many farmers, but its productivity is abating. Fortunately, the opportunities that postmodern agriculture is opening up in the 21st century are not limited to either richer or poorer farmers. The ubiquity and synergy of genetic potentials in plants and soil organisms is widely and freely available to all those who understand and respect them.

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Farming With the Wild: Foreword and Introduction

Fred Kirschenmann and Daniel Imhoff

Foreword

Fred Kirschenmann

As a farmer, my relationship with wild things has been fraught with ambiguity. I grew up believing that wildness was the enemy of agriculture. I didn't like blackbirds eating our sunflowers, coyotes attacking our calves, or weeds robbing our crops of nutrients and moisture. So I had an almost instinctive inclination to tear all the wild-ness out of our farm. I was ready to use all the tools or scientific management tactics available to eradicate wild things from the farm.

A part of me even felt morally justified in harbouring that attitude because it is deeply entrenched in our culture. The early Puritans who settled on New England's shores considered it part of their manifest destiny to 'tame the wilderness' and 'build the Kingdom of God' in this 'new land'. Cotton Mather (1663–1728) considered the wilderness to be the 'devil's playground'. It was, therefore, part of his God-given responsibility to urge his fellow Puritans to replace the wilderness with nice, neat rows of corn. For good or ill, that Puritan ethic shaped much of the culture in North America once Native Americans were driven from the land. I am a product of that culture.

Like the generations of farmers and ranchers before me, I have lived, in part, by this wilderness eradication ethic and caused devastating harm to natural ecosystems. Meanwhile, conservationists have adopted a countervailing ethic in order to protect the wilderness. In response to centuries of abuse, conservationists decided to preserve wilderness in its natural state by designating certain regions as Wilderness Areas that are to be protected from human activity. Only with great difficulty have wilderness advocates managed to keep a small proportion of our country

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(approximately 5 per cent) free from industrial intrusions (though not free of livestock). But by quarantining humans from certain parts of the landscape to preserve it, we have also inadvertently consented to humans using the rest of the landscape without any regard for its wildness.

We now know that this dual approach to land use is dysfunctional on both counts. Wildness cannot be 'maintained' in the form of isolated pieces of the landscape, and farms cannot be productively managed without wildness. Just as wild organisms need the connectivity of natural ecosystems to thrive, so agriculture needs the wildness of soil organisms to maintain soil quality and pollinators to grow crops – both necessary elements for productive farming. So in the interests of both productive farming and robust wilderness, we need to revisit our dualistic mentality.

Since producing as much as possible in one part of the landscape while preserving everything in its natural state in another part of the landscape is not working, and the real goals of conservation – preserving the integrity, stability and beauty of the biotic community – have been betrayed, we are now forced to come to terms with our fundamental role as *Homo sapiens* within the biotic community. The essential fallacy in our dualistic thinking is that in both cases – wilderness and agriculture – we had assumed that humans were separate from Nature. Isolating wilderness areas from human activity assumes that wilderness thrives best without human intervention. Indeed, large areas uninhabited by people such as the Brooks Range of Alaska provide powerful testament. That assumption, however, while probably true in the modern, industrial context, serves only to deepen the schism between humans and wild Nature. Isolating wildness from agricultural landscapes presumes that humans, acting separately from Nature, can control production systems purely with human ingenuity and technology. Neither assumption encourages the sort of healthy reintegration into the biotic community that humans must achieve – for our own sake and the sake of all life on Earth. Behind that dualistic fallacy lies another, namely that Nature is a given, that it has evolved into a state of equilibrium (that it will remain essentially the same) and that we can either manipulate it at will (agriculture) or preserve it in a natural stasis (wilderness). Again, there are no empirical data to justify such assumptions. And this both encourages the alienation of humans from Nature and represents a serious underestimation of Nature.

Fifty years ago Aldo Leopold attempted to overcome this flawed dualistic thinking by introducing a new paradigm – an 'ecological consciousness'. The role of *Homo sapiens*, he suggested, had to be changed from one of 'conqueror of the land-community to plain member and citizen of it'. This way of thinking, he suggested, transforms our relationship within Nature. It:

> reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land. Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity (Leopold, 1949).

When our understanding stems from this perspective, the boundaries between domesticated agriculture and wilderness begin to soften.

Our society's failure to appreciate the need for an ecological consciousness is evident not only on industrial farms, but on organic farms as well. We have, unfortunately, come to think of organic farms as isolated enclaves that have little or no connection with the ecology of the landscape in which those farms exist. Organic farms, treated as isolated enclaves, cannot maintain the rich biodiversity necessary for a healthy farm, any more than an isolated wilderness can preserve the biodiversity of a healthy ecosystem. If we hope to create an agriculture that ensures the land's capacity for self-renewal, or a wilderness that perpetuates the native biodiversity of a region, then humans who possess an ecological consciousness need to be part of the landscape.

It is, in part, our dualistic thinking that has led us to believe that the 'environment' exists of its own accord. It is just 'out there'. In truth, however, the environment is constantly being constructed by the organisms (including humans) who live in it. As Harvard evolutionary biologist Richard Lewontin (2000) reminds us, all organisms:

> are in a constant process of altering their environment. Every species, not only *Homo sapiens*, is in the process of destroying its own environment by using resources that are in short supply and transforming them into a form that cannot be used again by the individuals of the species.

In other words, if it were not for the activity of organisms in nature modifying their environment – and in doing so, destroying part of it – there would be no environment.

It is the process of one species destroying part of the environment that creates opportunities for other species. Cows eat grass, thereby destroying part of the environment. The by-product of that activity is manure, which provides food for dung beetles and other organisms, who in turn destroy the manure, and in so doing create nutrients for the soil to produce more grass. As Lewontin (2000) goes on to say, 'every act of consumption is also an act of production'. The appropriate role of humans, then, is to engage in a dance with other species in the biotic community in a manner that enables the community to renew itself – both its wild and domestic parts.

Applying such a view to 21st century agriculture will require a radical shift in our relationship with Nature. First and foremost, we must reclaim our solidarity with the ecosystems in which we farm through 'place-based reinhabitation'. As David Abrams has written: 'It is only at the scale of our direct, sensory interactions with the land around us that we can appropriately notice and respond to the immediate needs of the living world' (Abrams, 1996). Our mission as farmers and ranchers then, must evolve from providing adequate, affordable, nutritious food and practising good conservation to taking direct responsibility for the 'health of the land'. Our conception of science must change from one that invents technological innovations to solve human problems to sciences that engage in locally based conversations with Nature. Our notions of organic farms must change from enclaves of purity to habitats within ecosystems. The certification of individual farms must give way to standards and monitoring systems for certifying entire watersheds. At that point, agriculture's relationship to wildness will move from production enclaves to wild farm alliances and restoring interconnected healthy ecosystems.

On our own organic farm in North Dakota we have begun to appreciate the role of wild-ness in productive farming. We now use livestock breeds that have retained some of their 'wildness' and as a result our beef cows possess the instinct to protect their calves from coyotes until the youngsters are old enough to fend for themselves. We have discovered that maintaining a suitable habitat for pollinators and beneficial insects increases the productivity of our cropping system. By mimicking the 'succession' inherent in wild systems with crop rotations, we have eliminated the need for costly herbicides to control weeds. We hope that someday perennial polycultures will replace annual crops, eliminating the need for annual disturbance of agricultural lands. We are convinced that many additional benefits lie hidden in the vast resources of the prairie ecology in which we farm. Despite decades of research and education devoted to controlling Nature, we have a lot of catching up to do. We first need to comprehend how the prairie ecology functions so that we can better understand how to farm by accessing Nature's free ecosystem services while improving the land's capacity to renew itself. Once we achieve that understanding, our farm will become more profitable and more sustainable.

Given the depletion of fossil fuel resources, the inabilities of our farming regions to sustain any further agriculture-related degradation, our expanding human population and its impacts on biodiversity, many of the above changes will take place. But this will require that we abandon our dualistic thinking, adopt an ecological consciousness and erase the hard boundaries between tame and wild in our minds.

The Case for Farming with the Wild

Daniel Imhoff

On a rural roadside just north of Winters, California, with the summer sun so hot the air shimmers like a mirage, we stand between two radically different farming philosophies. Miles away to the west are the tawny and creviced hills that drain the wet-season rainfall of the Pacific Coast Range. Those waters eventually make their way to the Union School Slough, now actually a volume-controlled ditch, which meanders eastward through the irrigated row crops, orchards and livestock pastures of Yolo County. On the western side of the road, you get a sense of time travel, a feeling of what the land may have looked like in a former era. The bunch grasses and sedges that line the canal banks are bushy, tall and luminous. Farther out, above the understory, rises a canopy forest of willow, cottonwood and oak. In the water, a paddle of young mallards shadows their mother as she zooms for cover behind a curtain of grass.

Directly across the road to the east is a scene more typical of industrial agriculture in California's Central and Sacramento Valleys. The 180-degree shift is so dramatic that it almost takes your breath away. Between the field edge and the slough, a distance of perhaps 20 feet that includes a single-track dirt lane, the soil is sprayed and scraped bare and, in contrast to the scene just on the other side of County Road 89, looks like scorched earth. Both sides of the road are working farm operations that depend upon the Slough's water for production. It is early summer, and both farmers are in high production mode, weeding, irrigating and managing a hundred tasks. Just a few decades ago, I am told by the farmer on the west side, he too practised 'clean' farming and viewed weeds and non-crop vegetation as mortal enemies of modern agriculture. But as a Boy Scout leader he had studied conservation principles, and as a wildlife veterinarian he had visited hedgerows in England during a trip abroad. Not long after, he and his wife decided to begin improving wildlife habitat on their 500-acre farm, bringing its edges back to life. He devoted himself to studying California's original oak savanna and local ecosystems and began to establish seasonal wetlands and tailwater ponds to filter run-off. Eventually, some 50 species of native perennial grasses, forbs, rushes, shrubs and trees were planted around field borders, roadsides, riparian areas and other unused strips of the farm. Two decades later, beavers, carnivores, dozens of bird species including three types of owls, and up to ten threatened or endangered species find haven there. What he didn't realize at the time, was that he was also sowing the seeds for a change in agriculture itself. What looks like a move backward in time allowed him to move forward as both a farmer and lover of the land. Due in large part to his initiative, a community of conservation-minded farmers, local agencies and extension officers, and nonprofits has slowly been building the expertise, resources and momentum necessary to forge a new approach to farming in the region.

Across the country throughout the 1990s, similar discoveries, similar commitments, similar reversals of vision were occurring in widely separated areas. The essential role of native pollinators in local ecosystems and in agriculture and the crisis of their rapidly vanishing habitat were being researched in the Arizona desert. Native plant aficionados were seeking out remnants of prairies and beginning to collect, save and grow out seed for local restoration projects. After decades of clearing, draining and attempting to render marginal lands suitable for cultivation to 'feed the world', federal agencies were working with farmers to return those same fields to wetlands, grasslands and bottomland forests through perpetual easements. Partnerships between farmers, rod and gun clubs, land trust organizations and environmentalists were forming to carefully time farming practices with the migratory pulses of waterfowl and fish. Natural processes of flood and stream flow were being reintroduced into a few select riverside agricultural areas in California while lightning-ignited wildfires were being welcomed on a million-acre tract of grasslands in the New Mexico–Arizona–Mexico Bootheel region – both as means of regenerating the land. A few ranchers were making peace with large carnivores, while some dairy and beef farmers were bucking the livestock feedlot model and perfecting the art of small-scale rotational pasture systems. A Kansas geneticist was pursuing a vision of creating, through classical plant breeding, a self-seeding prairie of perennial grains that would require little fertilizer and no tilling, ideally adapted to its place on the land. The reassemblage of former free-roaming grassland species such as the bison, prairie dog, ferret, wolf and elk was beginning to take nascent shape in fragmented areas of the Great Plains. Throughout the mid-elevation coffee farms of Central America, biologists were discovering the critical link between habitat remaining on forest-shaded coffee farms and declining populations of migratory songbirds. There are more examples, many more, of people tuning in to both the small picture of their own farms and ranches and to the broader landscape, working in partnership with, rather than against, the surrounding natural world. It is time to give a name to what can only be described as a gathering movement: *fanning with the wild*.

This book has been the result of a multi-year research project to document and chronicle on-the-ground efforts to restore wild habitats within farming and ranching regions across the country. My interest in taking on such a challenging topic came from various personal experiences and sources of inspiration throughout the 1990s. As the owner of a remote 100-year-old apple orchard in Northern California's Anderson Valley, one frequented by wild turkeys, bobcats, screech owls, gophers, pileated woodpeckers, black bears (who eat fruit by the limb and must be discouraged if harvests are to be sustained), as well as an additional cast of wildlife too numerous to list, I was naturally inclined. As a freelance writer who reported on the organic industry for many years, I ultimately became convinced that the standards set for organic farm management had not necessarily taken into account a farm's impact on its watershed and surrounding ecosystems. One particular assignment for *Whole Earth Magazine* triggered a host of questions that led me to write further articles in *Sierra* and *Orion Afield*. Finally, as a part-time activist who had attended numerous presentations about the need for wildlands connectivity across the landscape, I encouraged John Davis and Mark Ritchie, programme officers at the Foundation for Deep Ecology, and Paula MacKay of the Wildlands Project to help me organize and host a conference on the topic. Held in January 2000, the small retreat resulted in the formation of the Wild Farm Alliance, now led by a nationally placed steering committee and advisory board of farmers, naturalists, educators, writers, gardeners and others that spend copious hours each month discussing the successes and shortcomings of promoting agricultural systems that are truly compatible with the full range of wild Nature. The need to produce a book that could help further the establishment of conservation communities across the country emerged as key tool for the organization. I eagerly volunteered and convinced my long-time collaborator, photographer and graphic designer Roberto Carra, to join me. Our hope was to assemble a vision of what interconnected, fully functional ecosystems and healthy farming communities might look like. We wanted to focus on positive examples rather than problems, and we wanted to keep our standards rigorous. Two years, 21 states and two countries later, we present what we hope is a unique yet inspiring view of the American landscape.

Industrial agriculture and the biodiversity crisis

At first glance, the phrase 'farming with the wild' may seem contradictory. Agriculture, by its very nature, has been and remains the relentless process of selection and minimization, one that now blankets billions of the Earth's acres with a mere handful of crops. Farming and ranching activities are consistently identified as the primary cause of habitat loss, the arch foe of the biodiversity crisis. Some 10,000 years ago, out of the cereal-bearing grasslands of the Fertile Crescent, out of the apple forested mountains of Kazakstan, out of the planet's 200,000-plus wild plant species and nearly 150 large wild mammalian terrestrial herbivores and omnivores – slowly and yet almost all of a sudden – there emerged the beginnings of what we now know of as the domestic (Diamond, 1997, p132). Ever since, agriculturalists have been diminishing native biodiversity in order to repopulate landscapes with utilitarian or desirable species. Size, sweetness, oiliness, fibre length, ease of cultivation, hardiness and vigour, self-pollination, yield, taste, nutrition, perishability, healing and recreational properties, colour: these were many of the lures for early agriculturalists as they developed place-based cropping systems. Throughout the millennia, agricultural domestication has largely been a dance of co-evolution, with humankind playing a leading role as artificial selector and steward, among a full cast of essential and cooperative participants (including birds, insects, fellow mammals, grasses, pulses, food and fibre plants and natural systems).

Many reaches we tend to imagine as wilderness – self-regulating and self-sufficient natural areas – may in fact have never been as completely free of human influence as we might think. First American societies were intensively managing some, but certainly not all, areas of the native landscape, using fire, for example, as a primary tool in maintaining open and vital grasslands. Yet through the conquest of the native landscape, the continental domination of European agriculture, and the rise of the global-industrial economy, never have the distances between farming and wildness been so vast or the human impacts on biodiversity so damaging. As Michael Pollan states solemnly in *The Botany of Desire: A Plant's-Eye View of the World:* 'Even the dream of such a space has become hard to sustain in a time of global warming, ozone holes, and technologies that allow us to modify life at the genetic level – one of the wild's last redoubts. Partly by default, partly by design, all of nature is now in the process of being domesticated – of coming, or finding itself, under the (somewhat leaky) roof of civilization. Indeed, even the wild now depends on civilization for its survival' (Pollan, 2001, pxxiii). This is a chilling realization and a far remove from Henry David Thoreau's edict that 'in wildness is the preservation of the world'.

At one time, thousands of plants were used for human food and agriculture. Today, no more than 120 plants provide 90 per cent of plant-supplied human food, oil and fibre needs; a mere dozen account for 80 per cent of the modern world's annual tonnage of all crops (Diamond, 1997, p132). In the 500-year period starting with Columbus's first voyage to the New World, colonization and world trade have transformed the biology and cultures of the Earth at dizzying speeds. It is hard to imagine that tomatoes were not a native element of Italian cuisine, that pre-Colombian Mexican food had no cheese, that Thai food's spicy chiles were adopted from Central America, or that potatoes were strictly South American and coffee East African. In the US, however, 98 per cent of the food production can be attributed to non-native species such as wheat, corn and cattle (Baskin, 2002, p26). According to Peter Vitousek at Stanford University, 40 per cent of the Earth's solar energy is directed toward food and fibre production for humans; up to 60 per cent of the world's freshwater resources are currently diverted for agriculture. With the rise of global corporate agribusiness over the past 60 years, the family farm has become a vanishing way of life in the US and elsewhere, and farming is no longer even officially recognized as an occupation by the Census Bureau. As farms that combined row crops and livestock gave way to specialized factory-oriented monocultures at war with pests, diseases and weeds, ever larger machinery necessitated ever larger areas to operate in. Fencerow-to-fencerow conversion of hedgerows, shelterbelts, wetlands and wildways increased the distance between agriculture and the natural world. Mechanical systems engineered to pump deeper and deeper groundwater disrupted basic hydrological functions in most farming regions. Corporate consolidation of farmland led to an ever increasing amount of rented acreage, on which landscape improvements became a low priority. Today, even the small farmer who is conscientious enough to manage farmland responsibly is continually squeezed by the pressure to produce more output for less money. Overgrazing, overplanting, overplowing, chemical-intensive regimens, extensive monocultures and other forms of land misuse are all symptomatic of efforts to make up for low prices by increasing production. Forced to compete in a globally oriented food and fibre system, farmers have often had to forsake goals such as wildlife preservation and long-term landscape conservation (as well as health care and other basic needs) in favour of short-term economic survival.

All the while, the correlation between our shopping lists and the Endangered Species List has been growing at an alarming rate. Farming and ranching activities now involve roughly two-thirds of the US land base in the Lower 48 states and are primary contributors to the imperiling of threatened species and ecosystems. Habitat destruction and fragmentation, the displacement of native species and the introduction of exotic species, pollution of terrestrial and aquatic ecosystems, soil erosion, the persecution of predators, the release of genetically modified organisms and the over-exploitation of non-renewable resources for food production and distribution are among the many ecologically devastating consequences of modern agriculture. In *America's Private Land: A Geography of Hope* published in 1996, for example, the US Department of Agriculture reported that farming activities contributed to 46 per cent of species listed as threatened or endangered, and ranching activities to 26 per cent (USDA, 1999, p54).

Modern agriculture's ecological footprint is drawn into particularly sharp focus by the issue of water development. Nearly two-thirds of the freshwater from lakes, rivers, streams and aquifers supply irrigation to about one-fifth of the agricultural land worldwide (Vickers, 2001). While the scarcity of freshwater is predicted to become the most important factor limiting agricultural production in the future (MacKay, 2001, p53), the technology to use that water remains tragically inefficient. According to the Wild Farm Alliance, US irrigation systems waste 50 per cent of the volume they use (World Resources Institute, 1998–1999). Globally, irrigation systems are only 40 per cent efficient (Wood et al, 2000). While these irrigated lands reap 35–40 per cent of the global harvest (Vickers, 2001), they impart a heavy burden on ecosystems, overdrafting groundwater at rates exponentially greater than the speed of natural replenishment, contaminating riparian systems with sediment and toxic chemicals, causing soil salinization in arid climates and dewatering entire lakes, rivers and freshwater systems. At last count, about 30 per cent of the protected species and the species proposed for protection in the US have been listed due to water resource development (Stein et al, 2000). Roughly a third of freshwater fish species globally are threatened with extinction (Soulé and Piper, 1992). The miraculous salmon runs, for example, that for millennia coursed dramatically through nearly every river system on the West Coast, have been decimated in just 150 years of settlement. The pallid sturgeon is now endangered in inland North American rivers due to lack of spawning sites and is joined by the Yaqui chub, the Topeka shiner and numerous others. Writing in *The Farm as Natural Habitat* (Jackson, 2002), Dr Laura Jackson, reports that '28 per cent of all amphibians, 34 per cent of fishes, 65 per cent of crayfishes, and 73 per cent of freshwater mussels are ranked extinct, imperiled, or rare by the Natural Heritage Network of the Nature Conservancy' (2002, p45). It comes as no surprise then that clashes over water rights between farmers, environmentalists, Indian tribes and urban dwellers have already hit the boiling point, exemplified by conflicts such as in the Klamath Basin in southern Oregon and Northern California and the Skagit Basin in north-western Washington. In September 2002, for example, an estimated 30,000 salmon died on the lower Klamath River, a catastrophic die-off that many people attribute to the diversion of water from the fishery to irrigated farmland. This century is sure to experience only more such escalation.

The dominating role of livestock and feedlot farming on the US agricultural landscape cannot be overestimated. More than 70 per cent of the national farm income is animal based. Of 1.2 billion total acres in agriculture, upward of 600 million acres of private lands (including tribal lands) and at least 250 million acres of public lands are used for grazing. Of the nearly 350 million acres of harvested crops, the majority of the top three crops – corn, soybeans and hay – are largely dedicated to feeding and fattening livestock. And an estimated 13 per cent of the ocean's fish harvests are diverted annually to cattle rations (Platt-McGinn, 1998, p15). Midwestern prairie systems that hold the vast potential to support free-ranging livestock (and native game set amid unbroken grasslands, wetlands, savannas and forests) have been converted into an ocean of corn and soybeans. More than a thousand miles away in the Gulf of Mexico, as a result of industrial corn and soybean production and concentrated animal feedlot operations (CAFOs), excess nutrients draining through the Mississippi River have generated a 8500 square mile dead zone of hypoxia, almost completely depleted of marine life (personal communication from Fred Kirschenmann to the Wild Farm Alliance). Still, much of the 130 million acres of corn and soybeans produced and consumed each year in the US remains largely invisible, as it is heavily processed or fed to animals before it reaches supermarket shelves and tables. For beef cattle, which evolved as grass eaters, the heavy corn diet wreaks havoc on their digestive systems, necessitating increasing use of antibiotics to stave off illness and infections (Pollan, 2002). While growing feed and hay to sustain animals through given periods is age old wisdom, confining as many as 100,000 animals in a CAFO where they never see the light of day, raises ethical questions on existential levels. According to Robert F. Kennedy, Jr., 'North Carolina's hogs currently outnumber its citizens and produce more fecal waste than all the people in California, New York, and Washington combined' (Kennedy, 1999, p66). Cattle production in the arid West is ecologically problematic as well. Though long established across the western landscape, cows, particularly at commercial levels, are largely unsuited for dry and fragile terrain, damaging creekbeds, harming soils, altering habitats and consuming vast quantities of irrigated supplemental hay and feed. While a number of contemporary initiatives to reform ranching impacts on arid lands are genuinely attempting to enhance biodiversity, the long-term ecological compatibility of cattle ranching in many arid regions remains in question.

In spite of this skewed land use system and other urgent ecological challenges, with the proper incentives, assistance and resources, farmers can and should be supported to manage their lands more sustainably, and profitably, while protecting wildland values. A love of the land, a managerial presence in rural and remote areas, years of experience, and a concern for native plants and animals are all common elements among farming communities. Practices such as pasture-based meat production, diversifying land use (growing vegetables, melons, fruits and herbs as well as field crops and animals, particularly for local markets), establishing wildlife corridors along river systems, and protecting critical natural areas on and adjacent to farms and ranches, have already shown great environmental and economic promise. Models and examples of landowners, land trust organizations, government cost-share and incentive programmes, third party ecolabels, wildlife monitoring groups, nonprofits and others working to achieve a compatible balance between farming and ranching activities and the protection of the natural world have emerged throughout the country in the past few decades.

A classic concept with a new vision

Farming with the wild is not a novel concept. 19th- and 20th-century American literature is replete with prophetic philosophical works that attempted to reconcile and redirect a civilization bent on the isolation or elimination of wildness from the broader culture. Henry David Thoreau's *On Walden Pond*, John Muir's *Mountains of California*, Aldo Leopold's *A Sand County Almanac*, Rachel Carson's *Silent Spring* and Wendell Berry's *The Unsettling of America*, spring readily to mind among the hundreds of works of extraordinary vision and insight. Within the sustainable agriculture movement itself, the idea that farms must be managed as natural systems gained considerable currency throughout the 20th century under a variety of names. The organic pioneer Sir Albert Howard insisted upon 'farming in Nature's image' after years of studying traditional agriculture in India. Rudolf Steiner re-envisioned the farm as a 'biodynamic' organism with its own self-sustaining animal-based fertilizers and cyclical patterns of planting, crop rotation and holistic management. US Department of Agriculture programmes of the 1930s were proactive and as concerned about sustainable agriculture as many present-day non-governmental efforts. J. I. Rodale popularized healthful eating and growing of organic foods and his son Robert advanced the practices and theories behind regenerative, organic agriculture. Aldo Leopold was and remains perhaps the country's, if not the world's, most eloquent advocate for the marriage of agriculture and conservation through a new 'land ethic'. Geneticist Wes Jackson's 'perennial polyculture' – an attempt to breed harvestable prairies that would be self-sufficient in fertilizer, weed and pest control – derived its design inspiration from the tallgrass prairie ecosystem. Today a number of terms and their movements describe the move away from monoculture toward polyculture, from an emphasis on annuals to geographically appropriate perennial cropping systems: agroecology, regenerative agriculture, natural systems agriculture, grass farming, succession farming, permaculture, ecoagriculture and farming with the wild.

Since the 1970s, organic farmers have been at the forefront of pioneering research in managing the farm as a natural system, demonstrating that nearly all crops can be grown without chemical inputs and successfully marketed on a variety of scales. Through the establishment of local marketing efforts and massive public education campaigns, the organic movement placed food and fibre production front and centre as a major public issue, and succeeded in linking a farmer and a face with the fruits and vegetables at the nation's tables. With growth rates of 20 per cent per year throughout the 1990s, organics has also become the fastest growing sector of the food industry. Willingly or unwillingly, the organic movement has been assimilated into the national and global economy, and at the turn of the 21st century, a proverbial Berlin Wall has begun to crumble. By 2008, the global organic industry is predicted to reach $80 billion with European Union governments dictating ambitious targets of the amount of arable land they want converted to organic production: Germany, 20 per cent; Belgium, The Netherlands and Wales, 10 per cent each (Baker, 2002). Despite the value of these successes, however, the emphasis of the organic movement has not been on managing farms at the watershed or ecosystem level in ways that complement and enhance the values and services provided by other landscape units such as large, strictly protected and interconnected ecological reserves. Such direct on-farm services of healthy ecosystems include pollination, biological insect and rodent control, nutrient cycling, the regulation of hydrological processes, erosion control, weed suppression and detoxification of chemicals. Instead, the organic agriculture movement has understandably focused its decades-long struggle on important issues less directly linked to biodiversity loss – keeping the family farmer on the land, developing non-toxic production practices and building markets for organic products. Under threat from development, the consolidation of processors and farmland, decreasing farm-gate prices, international competition and corporate domination, survival is at stake. With the mainstreaming of the organic movement, even the futures of small-scale farmers growing for local and niche markets now hang in the balance.

At the same time, spurred by critically plummeting wildlife populations in industrial farming areas, the US Department of Agriculture resumed the allocation of Farm Bill resources for conservation in farm areas in the mid- to late 1980s. What started as a series of pilot programmes (the Conservation Reserve Programme, Wetlands Reserve Programme, Wildlife Habitat Incentive Programme and others) has over nearly two decades resulted in the protection and/or restoration of tens of millions of acres of wetlands, bottomland forests and grasslands nationwide. While spending on conservation programmes remains marginal compared to the subsidies that prop up the mass production of only a handful of commodity crops, thanks to significant pressure from conservationists and environmentalists, as much as $2 billion could be spent on significant programmes in private lands in the coming decade. These efforts will help to expand the amount of wetlands under restoration and protection, fund a broad-scale grasslands conservation programme, target key habitats for imperiled species in agricultural areas and reward farmers for practices such as cover cropping and diversification. There is still much to be learned, however, to make these conservation programmes more ecologically and agriculturally effective.

Adding to this picture of the Lower 48 states, contemporary large-scale wilderness recovery initiatives have set forth a bold and urgent vision for the restoration of functional ecosystems over North America in the 21st century. According to the country's leading conservation biologists, our protected wilderness areas and national parks have become increasingly isolated through surrounding resource extraction and various forms of development. Many are unable to sustain viable populations of the species they harbour, resulting in genetic isolation, inbreeding and ultimately extirpation. As experts including Reed Noss, Michael Soulé and Dave Foreman argue, connecting those fragmented wilderness areas through networks of corridors and mixed-use buffer zones is urgently needed to expand habitat areas for wide-ranging species and to reverse the country's (and the world's) stemming biodiversity crisis.

The dire situation of biodiversity loss and proposals to restore native diversity across broad areas from Alaska to Central America have set the conservation and agricultural communities on a collision course. With such a large percentage of the US landbase in private hands and presently in agriculture – and much of that the most productive lands and habitat, which were settled long before the ethic of conservation took hold – a key to the North American wilderness recovery lies in working with farming and ranching regions. As one example, the Richmond, Vermont-based Wildlands Project, has been drafting strategies and creating maps to recover wilderness on a massive scale throughout North America – with an emphasis on ecosystem processes, the need for recovery of all species and the role of top carnivores to maintain ecosystem integrity. The Wildlands Project has been looking to other organizations, such as the Wild Farm Alliance, for ideas on establishing and maintaining high standards for wildlife-friendly agricultural activities in compatible-use areas.

In their unpublished essay 'Tame and Wild: Organic Agriculture and Wildness', North Dakota wheat farmer Fred Kirschenmann and his co-author David Gould argue for an ever closer merger between conservation biology and agriculture:

> We cannot have healthy 'organic' farms within degraded landscapes. Quite apart from the problem of 'drift' – whether chemical or genetic – there is the fact that the biodiversity necessary to produce the ecosystem services on which our organic farms depend can only be restored and maintained at the ecosystem level. It is the coevolution of a diverse array of species interacting with each other that gives nature its dynamic resilience – something Stuart Kauffman calls 'interacting dancing fitness landscapes' (Gould and Kirschenmann, 2000).

With this evolved thinking, a new vision for a more functionally integrated agriculture is emerging. Such a vision begins with farms that gracefully meld into landscapes supporting a wide – if possible, full – range of native species. Arable lands would be maintained in agriculture but would favour cropping systems that mimic the surrounding landscape, while marginally productive lands would be restored to native habitat. Every farm, while still functioning as its own healthy ecosystem, would in some way act as a corridor connecting it to a larger, ultimately wilder landscape – through clear and free-flowing watersheds, through woodlots and forests, grasslands, hedgerows or wetlands, eventually into roadless areas beyond human intervention. Society would do its part to actively encourage and support community-oriented farmers who grow a mix of crops native to or adapted to their different regions, and who are rewarded for not farming at the expense of native pollinators, carnivores, fish or any other members of wild Nature. Ultimately, entire regions could be recognized or certified by their 'wild' aspects. Such a vision, however, will require new ways of looking at agriculture's place on the landscape. Fortunately, a number of pioneering groups and individuals have already been 'farming with the wild' for a decade or more, and these models can help establish the basis for a nationwide, regionally oriented movement.

Emerging models and wild farm pioneers

Building alliances between historical adversaries will no doubt require tearing down decades-old walls and stereotypes: environmentalists, on the one hand, often lumped with wealthy urbanites and bureaucrats who dispatch regulations from distant power centres, and farmers and ranchers, on the other, frequently perceived as narrow-minded and steeped in a sense of entitlement. What may in fact help to bring both camps together in alliances is a sense of unity in common goals and common foes. Common goals would include maintaining arable farmland within healthy rural communities, keeping rural lands open and free from subdivision and development, restoring native habitat on private and public lands and creating a more natural urban–rural interface. Common foes might include land-exploiting absentee agribusiness corporations, massive concentrated animal feedlot operations and global versus regional food systems. In a recent essay on the subject, the Kentucky farmer and author Wendell Berry wrote:

> I am a conservationist and a farmer, a wilderness advocate and an agrarian. I am in favour of the world's wildness, not only because I like it, but also because I think it is necessary to the world's life and to our own. For the same reason, I want to preserve the natural health and integrity of the world's economic landscapes, which is to say that I want the world's farmers, ranchers and foresters to live in stable, locally adapted, resource-preserving communities, and I want them to thrive. One thing that means is that I have spent my life on two losing sides. As long as I have been conscious, the great causes of agrarianism and conservation, despite local victories, have suffered an accumulation of losses, some of them probably irreparable – while the third side, that of the land-exploiting corporations, has appeared to grow ever-richer. I say 'appeared' because I think their wealth is illusory. (Berry, 2002, p50)

Fortunately, throughout the country, rural communities are launching their own initiatives at the same time they battle the forces of urban development, consolidation in food processing, the globalization of commodity production, rock-bottom farm-gate prices and escalating costs, the flight of an agricultural infrastructure, increasing government regulations and a myriad of other woes. 'These efforts often begin slowly, with farmers and concerned citizens meeting together, talking, sharing, walking fields and grasslands, forming management teams, seeking advice from others', says the Land Stewardship Project's Dana Jackson, who is co-author and co-editor of *The Farm as Natural Habitat*. 'Later they can develop yardsticks to monitor their progress, becoming more conscious of the biological diversity in their regions, increasingly building the knowledge of how natural processes contribute to the farm and to the quality of rural life.'

Our relationship with food was once, and arguably should always remain, one of our deepest connections with the biotic community, for it ultimately determines what kinds of fellow beings we are. At this crossroads early in the 21st century, we face a revolution of no small proportions in how our food and fibre will be produced and at what economic, social and biological costs. Our society will determine, through policies and purchasing habits, through personal and communal commitments, what kinds of landscapes we support and what species remain on them. Farmers cannot be expected to shoulder the brunt of this burden. Without technical and financial assistance in the form of incentives and cost-share programmes, consumer-supported ecolabels and land trust collaborations, farming at the landscape level might remain limited to wealthy landowners and isolated conservation initiatives. Ultimately, success must come through collaboration and the articulation of a new vision for agriculture: consumers who support local producers because they are protecting biodiversity; skilled ecologists who can point the way toward restoration; local resource conservation districts, transportation departments and other programmes that promote and practise restoration in rural areas; financial mechanisms that ensure long-term protection of truly viable wildlife corridors.

The challenge of making agriculture more harmonious with biodiversity, particularly in the face of other social and economic factors, conjures more questions than ready answers. How wild is wild enough? Which species are benefiting and which species are losing from our management decisions? At whose expense should these efforts be made? What is the appropriate balance between agriculture and native biodiversity? Can we make a large-scale shift away from industrial feedlots and toward a more sustainable grass-fed meat economy, including migratory bison populations in appropriate areas and a mosaic of domesticated livestock husbandry in areas where the conditions of local ecosystems and access to markets are suitable? Can a new conservation ethic muster the political, economic and cultural forces necessary to accomplish a vision of farming with the wild? After decades of working in relative isolation, conservationists, farmers and sustainable farming activists are beginning to view agricultural areas as critical terrain in the effort to restore large and healthfully functioning ecosystems throughout the continent. New dialogues, new collaborations, new programmes indicate that such changes are indeed reshaping life down on the farm. We can only hope that time is on the wild's side.

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List of Acronyms and Abbreviations

AB	ecolabel (France)
AFD	alternate flooding and drying
ALPS	Accountability, Learning and Planning System
AOC	Appellation d'Origine Contrôlée
AWD	alternate wetting and drying
BMI	body mass index
BPH	brown planthopper (of rice)
BSE	bovine spongiform encephalopathy
CAP	Common Agricultural Policy
CDC	Cahier des Charges
CHD	coronary heart disease
CHNS	China Health and Nutrition Survey
CREE	Centers for the Production of Entomophages and Entomopathogens
CSA	community-supported agriculture
CVD	cardiovascular disease
DALY	disability adjusted life year
DFID	Department for International Development (UK)
ENSAT	École Nationale Supériere Agronomique de Toulouse
ETa	actual evapotranspiration
ETp	average potential evapotranspiration
EU	European Union
FAO	Food and Agriculture Organization (UN)
FCO	Foreign and Commonwealth Office
FES	Food Expenditure Survey
FFS	farmer field schools
FMD	foot and mouth disease
FTC	Federal Trade Commission (US)
GDP	gross domestic product
GMO	genetically modified organism
GNAU	National Urban Agriculture Group (Cuba)
GNP	gross national product
HACCP	Hazards Analysis Critical Control Point
HYT	High-Yielding Theory
HYVs	high-yielding varieties

IARC	International Agency for Research on Cancer
IASO	International Association for the Study of Obesity
IBRFP	Indo-British Rain-fed Farming Project
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDS	Institute of Development Studies
IGP	Indication Geographique Protegee
IHC	Interfaith Hunger Coalition (Southern California)
IMV	Institute of Veterinary Medicine
INGO	international non-governmental organization
INIFAT	National Institute for Fundamental Research on Tropical Agriculture (Cuba)
IP	In Process
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
LBW	low birth weight
LEIT	low external input technology
LR	Label Rouge
MA	Millennium Ecosystem Assessment
MBR	Maya Biosphere Reserve (Guatemala)
MDGs	Millennium Development Goals
NFS	National Food Survey
NGO	non-governmental organization
NHANES	National Health and Nutritional Examination Survey
NIB	National Irrigation Board (Kenya)
NIDDM	non-insulin-dependent diabetes mellitus
ODS	ozone-depleting substance
PPAs	participatory poverty assessments
PRA	participatory rural appraisal
PRB	Population Reference Bureau
rBGH	recombinant bovine growth hormone
RIPS	Rural Integrated Project Support (Tanzania)
SARS	severe acute respiratory syndrome
SOQ	Official Sign of Quality
SOQT	Sign of Quality of Transformed Foods
SPSS	Statistical Package for the Social Sciences
SRI	System of Rice Intensification
TEAs	tradable environmental allowances
TREE	Technology for Rural and Ecological Enrichment
TRIPS	Trade-related Aspects of Intellectual Property Rights
UFO	unidentified field observation
UNHCR	United Nations High Commissioner for Refugees
UPPAP	Uganda Participatory Poverty Assessment Process
USAID	United States Agency for International Development
USDA	US Department of Agriculture

vCJD	variant Creutzfeldt-Jakob Disease
WCD	World Commission on Dams
WP	water productivity
WTO	World Trade Organization

Editorial Introduction to Volume III

Jules Pretty

Food Systems Overview

Recent advances in aggregate farm productivity have only brought limited reductions in the incidence of hunger. At the turn of the 21st century, there were nearly 800 million people hungry and lacking adequate access to food, comprising 18 per cent of all people in developing countries. A third were in East and South-East Asia, another third in South Asia, a quarter in sub-Saharan Africa, and a twentieth each in Latin America and the Caribbean, and in North Africa and the Near East. Nonetheless, there had been progress to celebrate, as the incidence of undernourishment stood at 960 million in 1970, comprising a third of people in developing countries at the time. Since then, average per capita consumption of food increased by 17 per cent to 2760 kilocalories per day – good as an average, but still hiding a great many people surviving on less: 33 countries, mostly in sub-Saharan Africa still have per capita food consumption under 2200 kcal per day. The challenge remains huge.

There is also significant food poverty in industrialized countries. In the US, the largest producer and exporter of food in the world, 11 million people are food insecure and hungry and a further 23 million are hovering close to the edge of hunger – their food supply is uncertain but they are not permanently hungry. Of these, 4 million children are hungry and another 10 million are hungry for at least one month each year. Despite this progress in food output, it is likely that food-related ill health will remain widespread for many people. As world population continues to increase, until at least the mid 21st century, so the absolute demand for food will also increase. Increasing incomes will also mean people will have more purchasing power, and this will increase demand for food. But as diets change, so demand for the types of food will also shift radically, with large numbers of people going through the nutrition transition, as first described by Barry Popkin (*The Nutrition Transition: Diet and Diseases in the Developing World*, 2002; Academic Press). In particular, increasing urbanization means people are more likely to adopt new diets, particularly consuming more meat, fats and refined cereals, and fewer traditional cereals, vegetables and fruit.

As a result of these transitions towards calorie-rich diets, obesity, hypertension and type II diabetes have emerged as serious threats to health in most industrialized countries. A total of 20–25 per cent of adults across Europe and North America are now classed as clinically obese (with a body mass index > $30kg/m^{-2}$). In some developing countries, including Brazil, Chile, Colombia, Costa Rica, Cuba, Ghana, Mexico, Peru and Tunisia, overweight people now outnumber the hungry. Diet-related illness now has severe and costly public health consequences. According to the comprehensive Eurodiet study published in 2001 (http://eurodiet.med.voc.gr/first.html), 'disabilities associated with high intakes of saturated fat and inadequate intakes of vegetable and fruit, together with a sedentary lifestyle, exceed the cost of tobacco use'. Some problems do arise from nutritional deficiencies of iron, iodide, folic acid, vitamin D and omega-3 polyunsaturated fatty acids, but most are due to excess consumption of energy and fat (causing obesity), sodium as salt (high blood pressure), saturated and trans fats (heart disease) and refined sugars (diabetes and dental caries).

An important driver of change in the world food system will arise from increased consumption of livestock products. Meat demand is expected to rise rapidly with economic growth, and this will change many farming systems. Livestock are important in mixed production systems, using foods and by-products that would not have been consumed by humans. But increasingly animals are raised intensively, and fed with cheap though energetically inefficient cereals and oils. In industrialized countries, 73 per cent of cereals are fed to animals; in developing countries, some 37 per cent are used in this way. Currently, per capita annual demand in industrialized countries is 550kg of cereal and 78kg of meat. By contrast, in developing countries it is only 260kg of cereal and 30kg of meat.

At the same time as these changes, farmers in many parts of the world are finding it increasingly hard to make a living. One reason why they struggle is that the proportion of the food pound or dollar returning to farmers has shrunk. Fifty years ago, farmers in Europe and North America received as income between 45–60 per cent of the money consumers spent on food. Today, that proportion has dropped to just 7 per cent in the UK and 3–4 per cent in the US, though it remains at 18 per cent in France. So even though the global food sector continues to expand, now standing at $1.5 trillion a year, farmers are receiving a relatively smaller share. In recent decades, the value of food has been increasingly captured by manufacturers, processors and retailers. Farmers simply sell basic commodities, and others add the value. As a result, less money gets back to rural communities and cultures, and they in turn suffer economic decline. But if farmers are receiving such a small proportion of the food pound and dollar, what happens when they sell direct to consumers? Do their farms and landscapes change for the better?

The basic challenge for a more sustainable agriculture is to make best use of available natural and social resources. Farming does not have to produce its food by damaging or destroying the environment. Farms can be productive and farmers earn a decent living whilst protecting the landscape and its natural resources for future generations. Farming does not have to be dislocated from local rural cultures, as sustainable agriculture, with its need for increased knowledge, management skills and labour, offers new upstream and downstream job opportunities for businesses and people in rural areas. This suggests a logical need to emphasize agriculture's connections to local ecologies and communities.

When food is a commodity, there is little to stop over-consumption. There are no checks and balances to have us worry about the hidden costs of certain types of food production. Our current food system, despite considerable performance improvements in recent decades – it is faster, fitter and more streamlined – is still flawed. However, collective action by producers of food, by consumers and by novel mixtures of both groups can make a difference. It is possible to create new forms of relationship, trust and understanding, leading to new cognitive constructions of food and its cultures of production.

Two concepts are useful in this rethinking – the ideas of bioregions and foodsheds. Bioregionalism implies the integration of human activities within ecological limits, and bioregions are seen as diverse areas with many ecological functions. Bioregionalism can thus be seen as a self-organizing or autopoiētic concept, which connects social and natural systems at a place people can call home. Bioregions are real places where people want to live. They can take years to build, emerging from the interactions of people who are not indifferent to the outcomes. People leave their mark and in turn are shaped by local circumstances and cultures. The term foodshed has been coined to give an area-based grounding to the production, movement and consumption of food. Foodsheds have been described by Jack Kloppenberg as 'self-reliant, locally or regionally based food systems comprised of diversified farms using sustainable practices to supply fresher, more nutritious food stuffs to small-scale processors and consumers to whom producers are linked by the bonds of community as well as economy'.

The basic aim of regionalized foodsheds is twofold. They shorten the chain from production to consumption, so eliminating some of the negative transport externalities and helping to build trust between producers and consumers, and ensuring more of the food pound gets back to farmers. They also tend to favour the production of positive environmental, social and health externalities over negative ones through the use of sustainable production systems, leading to the accumulation of renewable assets throughout the food system.

Part 1: The Global Food System

The pursuit of increased productivity and conserved natural resources in the course of rural modernization has produced benefits in the form of improved food production and some improvements in resource conservation. The increases in food production have been significant. These improvements look so good that it is easy to be tempted to forget questions such as: 'What is the cost of this improvement?' 'Who benefits and who loses out?' Many would argue that the ends justify any reasonable means. Yet it is increasingly being recognized that the social and environmental costs of agricultural modernization cut deep into the fabric of society. Modernization in the urban environment has been characterized by alienation and conflict, increased individualism and a breakdown of communities. Much the same is true in rural environments. Jobs have been lost, environments polluted, communities broken up and people's health harmed.

All sectors of economies are affected. The drive for agricultural efficiency has drastically cut the numbers of people engaged in agriculture in industrialized countries. External inputs of machines, fossil fuels, pesticides and fertilizers have displaced workers in Green Revolution lands. Rural cultures have been put under pressure, as more people have been forced to migrate in search of work. Some local institutions, once strong, have become co-opted by the state or have simply withered away. Farms have become simplified and some resources, once valued on the farm, have become wastes to be disposed off the farm. Some external inputs are lost to the environment, so contaminating water, soil and the atmosphere. Agriculture has become more fossil-fuel intensive, so contributing to global warming. Overuse or continued use of some pesticides causes pest resistance and leads to pest resurgences, encouraging farmers to apply yet more pesticides. The first article by Jules Pretty reviews these thematic challenges, as well as analysing in detail case studies on pesticides in the Philippines, soil erosion in the US, Africa and India, social change in Britain, Japan and the US, modernism in Mexico, social change in rice cultivation areas of Indonesia, and conflicts between pastorialists and wheat farms in Tanzania.

The real agricultural challenges of the future will, as today, differ according to their geopolitical and socioeconomic contexts. The current divide between those who eat well and those who go hungry will continue, defined largely by differences in per capita incomes within and between countries. Factors that distinguish the various trajectories of agricultural development also exhibit significant spatial variability, such as differences in farming systems and productive capacity, population densities and growth, evolving food demands, infrastructure and market access, as well as the capacity of countries to import food or to invest in agricultural and environmental improvement. Environmental problems associated with agriculture also vary according to their spatial context, ranging from problems associated with the management of modern inputs in intensively farmed areas to problems of deforestation and land degradation in many poor and heavily populated regions with low agricultural potential.

In the second paper Robert Tripp summarizes the findings of a study that examined the performance of low external input technology in three major projects. The projects promoted soil restoration (Honduras), soil and water conservation (Kenya) and Integrated Pest Management (IPM, Sri Lanka). The focus projects were large and well managed and the study examined outcomes five or more years after project completion. An assessment of the utilization, adaptation and abandonment of the technologies found fairly consistent experiences that allow several general conclusions. In many instances, these methods make important contributions to farm productivity. Low external input technology is often labour-intensive and the growing importance of hired labour makes it difficult to see it always succeed. Its uptake patterns are similar to those of conventional technology (with commercial incentives particularly important). On its own, according to this study, it makes only modest contributions to strengthening human and social capital. Implications for the promotion and development of farmer organizations are discussed.

In the third article, the opener to the book *The Politics of Food*, Marianne Lien sets out how food has emerged as a political topic. Recent food scandals, such as the outbreak of bovine spongiform encephalopathy (BSE) and the public debate over genetically modified foods, have exposed many dilemmas in modern food production and consumption. This paper seeks to draw attention to some of the less obvious ways in which food is politicized. 'What's for dinner?' is no longer a simple question. Food is not only a commodity for consumption, but is politicized all the way into the kitchen and to the dinner table, with many implications for cooking and family care. Food is argued over in transnational fora, seen in different ways by experts ranging from nutritionists to anthropologists and regulated by governments the world over. Trust in food is culturally established and varies geographically (some eat dogs, others eat snails; many eat neither). At the same time, food is a connection to the natural environment, which may or may not have been affected positively by the types of production systems in use.

The fourth paper by Abha Mishra et al addresses the remarkable appearance of a new system of rice cultivation in recent years. Increasing demand for cereals produced from limited natural resources stimulated the Green Revolution in grain crops such as wheat and rice. But the gap between potential and actual production continues. Concerns about sustainability, and the social and technical shortcomings of the Green Revolution, have triggered a number of alternative crop production strategies. One, in particular, the so-called System of Rice Intensification (SRI), is attracting attention by governments and farmers in Asia and elsewhere. The suite of cultural practices that characterize SRI, including rapid and shallow transplanting of younger seedlings, more widely spaced and with reduced irrigation water, are all amenable to farmer experimentation and adaptation to suit local conditions. Thus, SRI encourages farmer participation in devising practical ways of growing a healthy crop in a sustainable manner. SRI develops a dynamic relationship between farmers, trainers and researchers, defining a clearer and distinct role for each in knowledge creation and innovation.

The science behind SRI is equally challenging, especially in relation to processes below ground level that affect soil ecology and root development. This paper reviews the evidence for each element of SRI. The relevant literature is extensive but has not been linked with the development of SRI, which was largely inductive, not guided by prior research. An integrated model is proposed that links root activity to grain yield. This model maintains the accepted paradigm that there is a significant relationship between a plant's cytokinin content and its response to the environment. This study makes clear that optimizing the plant/environment interaction for better yield through integration of biophysical issues is a challenging task given the diversity and location-specificity of production environments. This challenge is best met by actively engaging rice farmers and trainers, from the outset, in improving the production process.

In the final paper of this section, Thomas Dietz, Elinor Ostrom and Paul Stern provide a 2003 update on the Hardin thesis in a paper entitled *The Struggle to Govern the Commons*. As they indicate, Hardin's oversimplification in this tragedy of the commons was twofold: he claimed that only the state could establish institutional arrangements that could sustain the commons in the long-run, and presumed that resource users were trapped in a commons dilemma, and so therefore unable to create new solutions. The authors indicate that there is, of course, an enormous threat to ecosystems from inadequate governance, and state that 'developing effective governance systems is akin to a co-evolutionary race … successful commons governance requires that rules evolve'. Effective commons governance is easier to achieve when the resources can be monitored, when the rates of change in resources and technologies are moderate, when communities maintain frequent face-to-face communication, when outsiders can be excluded at relatively low cost and when users support effective monitoring and rule enforcement. The authors then set out the requirements for adaptive governance in complex systems, and these centre on (i) providing information, (ii) dealing with conflict, (iii) inducing rule compliance, (iv) providing infrastructure, (v) being prepared for change, (vi) ensuring analytical deliberation, (vii) nesting of institutional arrangements, and (viii) institutional variety. The paper shows that as the footprint of humanity on the earth enlarges, so 'humanity is challenged to develop and deploy understanding of broad-scale commons governance quickly enough to avoid the broad-scale tragedies that will otherwise ensue'.

Part 2: Poverty and Hunger

Robert Chambers is one of the world's foremost writers and innovative practitioners on approaches to agricultural development that build first on the knowledge and skills of the poorest. Their continuing exclusion from the economic and social benefits of rural development remains a scandal. In his 2005 book, *Ideas for Development* (Earthscan) Chambers draws together his experiences over four decades to indicate how we need to think differently as well as act differently if any lasting and significant contribution to poverty reduction is to be made. In this opening chapter, he reflects on settlement schemes in tropical Africa from the late 1960s and early 1970s. Here the emphasis is on our need to learn from experience. The second part of the chapter reviews subsequent developments with settlement schemes and then explores wider contemporary meanings, relevance and applications for these three key words: commitment, continuity and irreversibility. Throughout, the effects of biases and neglect in recent patterns of agricultural development are exposed and lessons suggested for the future.

One of the problems with trying to identify both priorities and action in agricultural development centres on our understanding of what 'improvement' means.

Agricultural development seeks to improve peoples' lives, or crop yields, or water quality or food supply. Yet it is a comprehension of what constitutes well-being and ill-being that should be the starting point. Both are states of mind and being. Well-being has a psychological and spiritual dimension as a mental state of harmony, happiness and peace of mind. Ill-being includes mental distress, breakdown, depression and madness – often described by people as the impacts of poverty. This article by Deepa Narayan and colleagues forms the second chapter in the World Bank sponsored study *Voices of the Poor*, in which perspectives of poverty are drawn from a wide range of countries. Despite the diversity of poor participants in the study, their ideas of well-being and what constitutes the good life were both multidimensional and had much in common. Interestingly, enough for a good life is not necessarily a lot, and for those with little, a little more can mean a great deal. Wealth and well-being are seen as different, and often contradictory. Descriptions of ill-being are also multidimensional and interwoven – yet how little do these perspectives appear in externally driven efforts to improve people's lives.

Lester Brown's 2002 book, *Who Will Feed China*, drew attention to the rapid economic development and accompanying consumption patterns within China, and how these could impact both local and international agricultural and food systems. We know that already many of the world's population now aspire to a US standard of living, and yet adoption of such lifestyles will be impossible. Increased population, for the first half of this century at least, combined with increased consumption, will, as Brown puts it, 'eventually collide with the earth's natural limits'. The first two chapters of this book provide an overview to these challenges, and the second focuses on population increase and associated policies. The latter is a Malthusian perspective – unless population growth is limited and stopped, the world's natural resource base will be more and more threatened. It is, though, population × consumption that is the key driver, and what is quite clear from Brown's analysis is that if so-called developing countries adopt the same consumption patterns as those already in industrialized countries, then ecological limits will soon be reached and breached. Alternative patterns of development and new aspirations will be essential.

Some of these alternatives will centre on the need to intensify agriculture (by producing more from the same lands), address rural poverty and protect or enhance biodiversity. In the opening sections to their book, *Ecoagriculture*, Jeff McNeely and Sara Scherr set out the challenge: a mutually supportive relationship between agriculture and the natural world needs to be developed. As Norman Myers has said, 'sensible use of nature … is essential to feed the planet… Nature equals food. Without wild places, we cannot hope to have food on our tables.' In this book, the management of landscapes for both the production of food and the conservation of ecosystem services, in particular wild biodiversity, is what the authors called ecoagriculture. Of course, this is easy to say but difficult to do. A wide range of genetic, technological, environmental management and policy innovations must be developed to support wild biodiversity in the world's bread baskets and rice bowls, as well as in the extensive areas where food production is more difficult.

And diverse approaches are indeed being developed and extended across many different environments and societies, both in developing and industrialized countries. The next challenge is to get some of these opportunities reflected in national and international policies.

What is the best way to increase agricultural productivity in developing countries that still, despite efforts over several decades, have some 800 million people short of food? The question is controversial, with widely varying positions about the types of inputs and technologies likely to be effective. Great technological progress in the past half century has not been reflected in major reductions in hunger and poverty in developing countries. However, many novel initiatives have emerged that are demonstrating that agriculture in poor countries can be greatly improved. In this fifth paper, Jules Pretty and colleagues evaluate how farmers in 286 projects in 57 countries had improved food crop productivity since the early to mid-1990s, and at the same time increased both water use efficiency and carbon sequestration and reduced pesticide use. These initiatives also offer the prospects of resource-conserving agriculture both reducing adverse effects on the environment and contributing to climate change mitigation. These 286 recent interventions in 57 poor countries covering 37Mha (3 per cent of the cultivated area in developing countries) had increased productivity on 12.6 million farms whilst improving the supply of critical environmental services. The average crop yield increase was 79 per cent (geometric mean 64 per cent). All crops showed water use efficiency gains, with the highest in rainfed crops. Potential carbon sequestered amounted to an average of 0.35t C ha^{-1} y^{-1}. Of projects with pesticide use data, 77 per cent resulted in a decline in pesticide use by 71 per cent whilst yields grew by 42 per cent. Whilst it is uncertain whether these approaches can meet future food needs, there are grounds for cautious optimism, particularly as poor farm households benefit more from their adoption.

Part 3: Diet and Health

Eve Balfour's classic 1940s book, *The Living Soil*, is seen by many as a key text in the establishment of the organic movement. She was both a farmer and a thinker, and contributed substantially to the national understanding of the connections between farming systems, and the soil on which they are based, and the effects of food on health. She asks, 'what shall I eat that I may be whole?' The types of foods and the balance between them fundamentally affects our health, and yet for many decades in the latter part of the 20th century this seems to have been forgotten. In this chapter, Balfour draws on a variety of cultures to illustrate how important diets are to health. The first is the people of the Hunza, now part of the northern areas of Pakistan. They were healthy people at the time, with all their foods locally derived. Today, they are more connected to external markets, but still rely on a variety of healthy foods. Other examples in the chapter draw on analysis of Faroe

Islanders and Iceland, native Eskimos (as they were then known), and the people of rural China (using F. H. King's book).

Barry Popkin of the University of North Carolina made a significant contribution to our understanding of changing diets by coining the phrase 'the nutrition transition'. Human history is, of course, characterized by many changes in diets and nutritional status, but the pace of change has considerably quickened in recent decades. The most recent nutrition transition has created an age of degenerative diseases and conditions that are avoidable, but only if there are rapid changes in both diet and levels of physical activity. Popkin sets out five periods in human populations: the age of collecting food, the age of famine, the age of receding famine, the age of degenerative diseases and the age of behavioural change. The last is yet to occur in industrialized countries. Across all industrialized countries, and increasingly in wealthier populations in developing countries, people have adopted diets containing 'superior grains' (rice or wheat instead of maize or millet), more milled and polished grains, food higher in fats, more animal products, more sugar and more food either prepared away from the home or processed.

The third article is drawn from Tim Lang and Michael Heasman's book *Food Wars*, and focuses on diet and health, and what has occurred during the recent experiment with modern agricultural systems that has focused primarily on increasing food production without concern for what has been lost. Modern agriculture has produced a commodity-based food system, and the diets of the majority of people in industrialized countries have shifted enormously. Food-related ill health now exceeds the costs of smoking in Europe and North America, with obesity, type II diabetes, cardiovascular diseases, diet-related cancers and osteoporosis on the increase. There are now some 1.7 billion people worldwide who are overweight – in a world where 800 million people remain hungry on a daily basis. Lang and Heasman set out details of this nutrition transition, and indicate precisely how diet composition has changed. We are now in a world where there are large numbers of underfed, overfed and badly fed, and this of course raises significant questions for policy makers who are largely yet to grasp the need for fundamental change.

Marion Nestle's book, *Food Politics*, is subtitled 'how the food industry influences nutrition and health', and this opening chapter indicates the extent to which diets and food choices are cleverly shaped by corporate interests, and how these of course affect people's health. The food industry has given many people in the world a plentiful food supply that is both varied and inexpensive, as well as devoid of dependence on geography and season. In the US, food supply is so abundant that it contains enough food to feed everyone in the country nearly twice over. To satisfy shareholders, food companies must convince people to eat more of their own products instead of those of competitors, and this requires considerable investment in advertising and public relations that is not only targeted at consumers, but at government officials, nutrition professionals and the media. Nestle shows how food companies use political processes (entirely conventional and nearly always legal) to obtain the support they need for the sale of their products. This opening chapter reviews what constitutes a healthy diet, shows why diet does matter and analyses whether Americans overeat. A review of the structures and actors in the US food industry then follows, including how marketing imperatives drive taste, cost, convenience and confusion. Through all this is the corporate need to promote eating more, especially amongst children, who then get the habit for life.

Eric Schlosser's book *Fast Food Nation* deservedly received great public attention. It has a clear and simple message, and documents just how fast food has come to dominate diet and life in the US. It could be said to be simplistic, in identifying corporate institutions as the main protagonists of dietary change. On the other hand, the obesity crisis emerged quietly at the end of the 20th century, with only 6 per cent of adults obese in the early 1980s, and 25 years later it affects more than 25 per cent. In this chapter, Schlosser explores the wide range of approaches taken by a single restaurant corporation, McDonalds. It is modernism at its most effective – a common language and culture spread across all employees, all restaurants, in all countries where they operate. The focus on children as customers (not the parents) is clearly exposed – advertising is directed to children, who use their 'leverage' or 'pester power' to affect the behaviour and choices of adults. Fast food companies spend $3 billion annually on television advertising in the US. In the late 1970s, a teenager drank 7oz of soda daily; today it is three times as much. This is liquid candy or empty calories, serving just to increase the incidence of obesity.

Part 4: Localized Food Systems

In the first article, Jack Kloppenburg and co-authors set out the compelling concept of the foodshed, and indicate just how connections to food and place can make a difference for both consumers and producers. As they say, 'if we are to become native to our places, the foodshed is one way of envisioning that beloved country'. They, too, though, show that fundamental changes are required if we are to evolve more ecologically and socially responsible agricultural and food systems. This raises questions about the nature of economies as a whole – are they simply geared in such a way so as to prevent sensible outcomes for people and nature? Or can they be changed too? The idea of the foodshed, a socio-geographic space, in which human activity is embedded in the natural integument of the particular place, is powerful and could help to provoke some serious rethinking about whole agricultural systems and their sustainability.

There are many perspectives on what constitutes sustainability and how it can be applied equally across agricultural contexts. As a result, a variety of analytical approaches have been developed, including energy accounting, economic valuation of non-marketed goods and services, ecological footprints, carbon accounting and the use of indicators for sustainability. Most of these approaches have only focused on environmental impacts up to the farm gate, and have not assessed the additional environmental effects of transporting foodstuffs via processing to retail outlets and then to the point of consumption. Evidence is mounting that these farm to plate transport costs, or 'food miles', are substantial. In addition, there is growing interest in local and regionalized food supply systems and the potential social and environmental benefits they could bring. This study by Jules Pretty, Tim Lang and colleagues analyses the full costs of foods in the average weekly UK food basket by calculating the costs arising at different stages from farms to consumers' plates. Of the 12 commodities assessed, livestock produce contributes the most costs per kg. Agricultural and food produce accounts for 28 per cent of goods transported on UK roads, currently imposing estimated external costs of £2.35bn yr^{-1}. The contribution made by sea and air transport is currently trivial owing to low volumes. However, road transport to carry food from the shop to home is estimated to impose a further £1.28bn yr^{-1} to total external costs. The paper assesses a variety of scenarios for the adoption of organic farming, localized food systems and sustainable transport to indicate the substantial potential to reduce environmental costs in the UK food system.

Facing a major agricultural crisis, European countries are searching for alternatives to the intensive-production agricultural development model promoted since the early 1950s. Agenda 2000 introduced significant changes in the Common Agricultural Policy (CAP) by recognizing the multifunctionality of agriculture and by giving more importance to the second pillar, a term used for the measures supporting wider rural development. Meanwhile, agri-environmental schemes are taking on much greater importance in the overall policy mix for agriculture in European Union (EU) countries. With respect to the idea of multifunctional agriculture, one way to raise farmers' environmental stewardship is to reward environmental practices through food quality labelling schemes. The objective of this study by Genevieve Nguyen and colleagues was to identify existing relationships between the production of quality food and the production of environmental goods at the farm level. In this paper, we report the results of analyses conducted to examine the effects of major 'quality' and 'ecolabelling' schemes in the Midi-Pyrenees regions of the south of France. Factor analysis and analysis of variance were used with a data set of 107 farms – some participating in the labelling schemes and some not participating – for which environmental scores had been assigned. The statistical analyses were complemented by a qualitative analysis based on in-depth interviews of 85 farmers and review of the labelling standard guidelines. This study shows that organic farms and farms enrolled in various quality and eco-labelling programmes in France do provide some environmental benefits. However, they do not necessarily perform better than other farms on all environmental measures.

At the turn of the century, Cuba was of the few developing countries in the world with an explicit national policy for sustainable agriculture. To the end of the 1980s, Cuba's agricultural sector was heavily subsidized by the soviet bloc. It imported more than half of all calories consumed, and 80–95 per cent of wheat, beans, fertilizer, pesticides and animal feed. It received three times the world price for its sugar. But in 1990, trade with the soviet bloc collapsed, leading to severe shortages of all inputs. The government's response was to declare an 'Alternative

Model' as the official policy – an agriculture that focuses on technologies that substitute local knowledge, skills and resources for the imported inputs. Two important strands to sustainable agriculture in Cuba have emerged. First intensive organic gardens have been developed in urban areas – self-provisioning gardens in schools and workplaces (*autoconsumos*), raised container-bed gardens (*organoponicos*) and intensive community gardens (*huertos intensivos*). There are now more than 7000 urban gardens, and productivity has grown from 1.5kg per square metre to nearly 20kg per square metre. Second, sustainable agriculture is encouraged in rural areas, where the impact of the new policy has already been remarkable. This paper by Nelso Companioni and colleagues is from Fernando Funes' book *Sustainable Agriculture and Resistance*, which documents in detail these agricultural changes in Cuba. This chapter focuses on the urban agriculture component, and shows how small areas of urban land have made such significant contributions to national food security. Urban agriculture is important to families in many countries, yet it is often forgotten by policy makers.

In the final article in this volume, Terry Marsden explores the quest for ecological modernization in industrialized food systems. He focuses on challenging the prevailing economic notions of scale, critical mass and centralization, and suggests that ecological modernization raises a new question: 'how could/should the contested relationships between civil society, the state and the market be rearranged in ways which would usher in different types of autonomous development which would incorporate ecological worth?' Through three areas, agriculture, restructuring food supply chains and forestry, Marsden explores how ecologically modernizing processes are operating in industrialized societies, and how these in turn are influencing rural development trends. As ecology has emerged as an important objective, so it has become embedded more into the institutions of economy. Might this lead just to a stronger growth treadmill, or a different and possibly more robust rural development paradigm? What does this mean for specific sectors? In South Wales, for example, forestry authority attempts to encourage more participation and inclusion in forested areas is constrained by deprivation in local communities, where other state services are being withdrawn. Food deserts in large cities are enclaves hidden from most who see corporate-led retail outlets as being abundant and cheap, rather than missing. Monopolistic retail arrangements affect the marginalized in society the most. And common to many places, primary producers who are, of course, nearest to the land, are being gradually discouraged as regulators seek to protect consumers, and corporations themselves acquire most of the value in the food chain.

Part I

The Global Food System

1

The Environmental and Social Costs of Improvement

Jules Pretty

But when the motor of a tractor stops, it is as dead as the one it came from. The heat goes out of it like the living heat that leaves a corpse. Then the corrugated iron doors are closed and the tractor man drives home to town, perhaps twenty miles away, and he need not come back for weeks or months, for the tractor is dead. And this is easy and efficient. So easy that the wonder goes out of the work, so efficient that the wonder goes out of the land and the working of it, and with the wonder the deep understanding and the relation.

John Steinbeck, *The Grapes of Wrath*, 1939

The General Costs of Improvement

The pursuit of increased productivity and conserved natural resources in the course of rural modernization has produced benefits in the form of improved food production and some improvements in resource conservation. The increases in food production have been significant. Despite the world population more than doubling in the past 50 years to some 5.6 billion, food production per capita has been able to keep pace. Over the same period, the amount of land conserved or protected has also increased. In the tropics alone, the land devoted to national parks and protected areas has grown from 58 to 174 million ha.

These improvements look so good that it is easy to be tempted to forget: 'What is the cost of this improvement?' 'Who benefits and who loses out?' Many would argue that the ends surely justify any reasonable means. Yet it is increasingly being recognized that the social and environmental costs of agricultural modernization cut deep into the fabric of society. Modernization in the urban environment has been characterized by alienation and conflict, increased individualism and a breakdown of

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communities. Much the same is true in rural environments. Jobs have been lost, environments polluted, communities broken up and people's health damaged.

All sectors of economies are affected. The drive for agricultural efficiency has drastically cut the numbers of people engaged in agriculture in industrialized countries. External inputs of machines, fossil fuels, pesticides and fertilizers have displaced workers in Green Revolution lands. Rural cultures have been put under pressure, as more and more people have been forced to migrate in search of work. Local institutions, once strong, have become co-opted by the state or have simply withered away. Farms have become simplified and some resources, once valued on the farm, have become wastes to be disposed off the farm. Some external inputs are lost to the environment, so contaminating water, soil and the atmosphere. Agriculture has become more fossil-fuel intensive, so contributing to global warming. Overuse or continued use of some pesticides causes pest resistance and leads to pest resurgences, encouraging farmers to apply yet more pesticides.

Environmental pollution and contamination by agriculture

The agricultural production increases brought about by high input packages have brought great benefits. Without them many people would be worse off than they are now; many others might have died of starvation. But in order to assess the true net benefits of high input packages, it is important also to understand some of the external costs.

The environmental problems caused by farming are a direct result of an increasingly intensive and specialized agriculture. The mixed farm can be an almost closed system, generating few external impacts. Crop residues are fed to livestock or incorporated in the soil; manure is returned to the land in amounts that can be absorbed and utilized; legumes fix nitrogen; trees and hedges bind the soil, and provide valuable fodder, fuelwood and habitats for predators of pests. In this way the components of the farm are complementary in their functions. There is little distinction between products and by-products. Both flow from one component to another, only passing off the farm when the household decides they should be marketed.

Over the last half century, many such highly integrated systems have disappeared. Farms have become more specialized with crop and livestock enterprises separated. Intensification of agriculture has meant greater use of inputs of pesticides, fertilizers and water, and a tendency to specialize operations. The inputs, though, are never used entirely efficiently by the receiving crops or livestock and, as a result, some are lost to the environment. Some 30–80 per cent of applied nitrogen and significant but smaller amounts of applied pesticides are lost to the environment to contaminate water, food and fodder and the atmosphere (Conway and Pretty, 1991). Water is often wasted or used inefficiently, leading to groundwater depletion, waterlogging and salinity problems. This is not only wasteful, but costly to those who want to use these resources and expect them to be uncontaminated.

Many environmental and health impacts have increased in recent years; others have continued to persist despite all efforts to reduce them (Conway and Pretty, 1991). Water systems have become increasingly contaminated. Nitrate in water can give rise to the condition methaemoglobinaemia in infants and is a possible cause of cancers. Pesticides contaminating water can harm wildlife and exceed drinking water standards. Nitrates and phosphates from fertilizers, and organic wastes from livestock manures and silage effluents all contribute to algal growth in surface waters, deoxygenation, fish and coral deaths, and general nuisance to leisure users. Eroded soil also disrupts watercourses, and run-off from eroded land causes flooding and damage to housing, irrigation systems and natural resources.

Various pollutants also harm farm and local natural resources. Pesticides damage predator populations and other wildlife and induce resistance in target pests. Nitrates from fertilizers and ammonia from livestock waste disrupt nutrient-poor wild plant communities. Metals from livestock wastes raise metal content of soils, and pathogens in wastes can harm human and livestock health. The atmosphere is contaminated by ammonia, which plays a role in acid rain production; nitrous oxide derived from fertilizers, which plays a role in ozone layer depletion and global warming; and methane from livestock and paddy fields, which also affects global warming.

The consumer is most likely to be directly affected by eating food contaminated mainly by residues of pesticides, but also by nitrates and antibiotics. In the industrialized countries, the levels of pesticides in foods have been falling steadily since the 1950s (Conway and Pretty, 1991; WPPR, 1994; Gartrell et al, 1986a, 1986b). Nonetheless, there are occasional public scares over particular products and rare incidents of severe poisoning arising from the spraying of illegal products. But in developing world countries, daily intakes are often very high. These may be in cereals, such as in India (Kaphalia et al, 1985; Sowbaghya et al, 1983); in fish, such as from rice fields in Malaysia (Chen et al, 1987) or lakes and rivers of Kenya, Nigeria and Tanzania (Atuma, 1985; Atuma and Okor, 1985); and in milk from cows affected by spray drift from cotton plantations in Nicaragua and Guatemala (ICAITI, 1977).

But the major hazard lies in locally marketed food. Leafy vegetables are often sprayed twice a week and may come to market with a high degree of contamination, especially in the dry season. Over 50 per cent of green leafy vegetables collected around Calcutta during the dry winter months contained residues, though this fell to 8 per cent in the wet season (Mukherjee et al, 1980). In Indonesia, cabbages and mustard greens have been found to contain organophosphates many times in excess of human tolerance limits (Darma, 1984). Similar levels of contamination have been recorded from Africa (Atuma, 1985).

These costs of environmental damage are growing, and are dispersed throughout many environments and sectors of national economies. For a comprehensive review of the effects of agricultural pollution on natural resources, wildlife and human health see Conway and Pretty (1991). What has characterized recent analyses has been the recognition that farmers themselves are suffering declining incomes or health effects from these modern approaches to agriculture. The following sections consider the issues of energy consumption by agriculture, pest resistance and resurgences, health impacts of pesticides and soil erosion.

Energy consumption by agriculture

A largely hidden cost of modern agriculture is the fossil fuel it must consume to keep outputs high. Modern agriculture has tended to substitute external energy sources for locally available ones. With the increasing use of nitrogen fertilizers, pumped irrigation and mechanical power, which are all particularly energy intensive, agriculture has become progressively less energy efficient. These three account for more than 90 per cent of the total direct and indirect energy inputs to farming in developing world countries (Leach, 1985, 1976). Mechanization reduces the labour required for agriculture and so can cut variable costs if energy is cheap, as it is in most industrialized countries. But for poorer countries, mechanization forces increased foreign exchange expenditure on fuel, oil, engines and spares.

There have been many approaches to energy accounting for agricultural systems (Leach, 1976, 1985; Stout, 1979; Stanhill, 1979; Pimentel, 1980; Smil et al, 1982; Dovring, 1985; Pimentel et al, 1989; OECD/IEA, 1992; OECD, 1993). These use such a variety of conventions that it is difficult to make direct comparisons. Some include only the direct fossil fuel energy consumed on farms; others seek comprehensive energy balances by including all the indirect energy consumed in manufacturing equipment and inputs, transporting produce to and from farms, and the energy required to feed human and animal labour on the farm. Direct energy represents what is immediately vulnerable to supply interruptions and so is of more immediate interest to farmers. In general, apart from nitrogen fertilizers, the manufacture of which is extremely energy intensive, direct energy costs far exceed indirect costs (Leach, 1985).

With the greater use of machinery, fuel and nitrogen fertilizers in modern high input agriculture, energy consumption is substantially greater than equivalent low input or organic systems (Table 1.1). In the Philippines, for example, a doubling of yields comes at the cost of an 8- to 30-fold increase in energy consumption. In India, a 10–20 per cent increase in yields following mechanization costs an extra 43–260 per cent in energy consumption. And in the US, high input systems can consume 20–120 per cent more energy than low input systems, even though yields may be comparable. Larger farms also tend to use relatively more energy than smaller ones. In the Punjab, farms in a class 14–25ha use three times as much direct energy per hectare as farms smaller than 6ha (Singh and Miglani, 1976).

Comparisons within countries or even regions are much more likely to be reliable than those between countries, as so many confounding factors become important. However, a comparison of the energy consumption across systems is revealing, if only at the level of orders of magnitude (Table 1.2). Low input, resource-conserving systems of production are much more energy efficient than the high input systems typical of industrialized countries. Low input or organic rice in Bangladesh, China, and Latin America can produce 1.5–2.6kg cereal per MJ of direct energy consumed. This is some 15–25 times more efficient than irrigated rice produced in the US.

Table 1.1 *Impact of modernization of agricultural systems on yields and direct energy consumption*

Country	*Low input comparison*	*High input comparison*	*Amount of extra yield for high input*	*Amount of extra energy consumption for high input*
Philippines[1]	Traditional rice	Modern rice	+116%	+3000%
	Rainfed rice	Irrigated rice	+150%	+800%
	Irrigated rice with *Azolla*	Irrigated rice with N	+0–30%	+200%
India[2*]	Bullock, rice	Power tiller, rice	+8%	+43%
	Bullock, rice	Tractor, rice	+13%	+74%
	Bullock, wheat	Power tiller, wheal	+12%	+89%
	Bullock, wheat	Tractor, wheat	+6%	+266%
India[3*]	Bullock, rice	Mechanized, rice	+20%	+45%
	Bullock, wheat	Mechanized, wheat	+29%	+138%
US[4]	Low input, maize	Conventional, maize	+0%	+120%
US[5]	Organic, wheat	Conventional, wheat	+29%	+48%
US[4]	Low input, maize	Conventional, maize	+0%	+22%

Note: For the sake of comparisons, the data in this table refer to direct energy use plus indirect energy for manufacturing fertilizers and seeds. These are not comprehensive energy accounts, in which all embodied energy is included. For those marked *, only direct energy is included. 1 Luzon 2 West Bengal 3 Uttar Pradesh 4 Midwest 5 Pennsylvania and New York.

Sources: FAO, 1976; Leach, 1976; Singh and Singh, 1976; Pimental et al, 1989; Berardi, 1978; Ikerd et al, 1992

In industrialized countries the trend has been towards the substitution of inexpensive fuel energy for expensive human labour, so making agriculture a significant energy consumer. Since the 1940s, some 25 million draft animals and 9 million agricultural workers have been replaced in the US; and in the UK, 340,000 jobs have been lost (Berardi, 1978; MAFF, passim). Energy consumption has increased too. According to the OECD (1993), the absolute energy consumption per hectare has increased in OECD countries by 39 per cent from 1970 to 1989. On average, some 1734MJ are consumed per hectare of agricultural land, rising to 46,400MJ for the highest consumer, Japan.

One consequence of this increased substitution of energy for labour in agriculture is a growing contribution to global warming. Agriculture is a major direct source of atmospheric pollution, emitting methane, nitrous oxide, ammonia and the various products of biomass burning (Conway and Pretty, 1991; IPCC, 1990). The single main cause of global warming, however, is carbon dioxide, estimated to contribute about half of the projected warming over the next 50 years. Agriculture contributes to CO_2 production directly through the burning of biomass and indirectly

Table 1.2 *Amount of cereal produced (kg) per megajoule (MJ) of direct energy input different agricultural systems*

Location	*System of production*	*No. of kg cereal produced per MJ of direct energy (+ indirect energy for fertilizers and pesticides used (kg/MJ)*
Japan	Irrigated, high input rice	0.30
China	Organic rice	1.53
Philippines	High input, irrigated rice	0.22–0.36
	Low input, irrigated rice with *Azolla*	0.79
	Rainfed, upland rice	0.72–0.88
Latin America	Low input, upland rice	1.94
Bangladesh	Low input, deepwater rice	2.64
USA	High input, irrigated rice	0.09
USA	High input maize	0.25
	Low input maize, alternative rotations	0.67
UK	Very high input wheat	0.45
	Low input wheat	1.09

Sources: Adapted from IRRI, 1981; FAO, 1976; Walters, 1971; Pimentel et al, 1989; Leach, 1985

through its consumption of energy produced by fossil fuel burning. For each kilogramme of cereal from modernized high input conditions, 3–10MJ of energy are consumed in its production; but for each kilogramme of cereal from sustainable, low input farming, only 0.5–1MJ are consumed. A shift to low input systems could, therefore, have an impact on the process of global warming.

However, there is considerably more energy consumed between the farm and the consumer. In the US, it is said that food travels on average 3000km from farm to plate. In Britain, the production of a 1kg loaf of bread consumes some 20.7MJ (equivalent to 0.48kg of oil), of which 80 per cent is consumed by milling, baking, transport and retailing (Leach, 1976). Making agriculture more energy efficient, by transferring to low input sustainable processes, could only decrease the energy consumed in the remaining 20 per cent. This could reduce the energy consumed in a loaf of bread to 16–17MJ. However, for cereals processed and consumed on the farm, or those passing through fewer processing or transport stages, significant improvements in energy efficiency could be possible following a transition to a more sustainable agriculture.

Pesticide-induced pest resistance and resurgences

The reason for applying pesticides is to prevent pest damage, yet unfortunately they can cause outbreaks themselves. Pesticides can be inefficient for several reasons (Conway, 1971; Risch, 1987). They can cause resurgences by killing off the natural enemies that control pests. They can produce new pests, by killing off the natural enemies of species which hitherto were not pests. And they can induce resistance in pests to pesticides.

Resistance can develop in a pest population if some individuals possess genes which give them a behavioural, biochemical or physiological resistance mechanism to one or more pesticides. These individuals survive applications of the pesticide, passing their genes to their offspring so that with repeated applications the whole population becomes resistant. High and frequent applications of pesticides exert the greatest selection pressure on populations. Resistance has now developed in all insecticide groups and at least 480 species of insect, mite or tick have been recorded as resistant to one or more compounds (Georghiou, 1986). Resistance has also developed in weeds and pathogens. Before 1970, few weeds were resistant to herbicides but now at least 113 withstand one or more products. Some 150 fungi and bacteria are also resistant (WRI, 1994).

Unfortunately, natural enemies appear to evolve resistance to pesticides more slowly than herbivores, mainly because of the smaller size of the natural enemy populations relative to pests and their different evolutionary history (Risch, 1987). The co-evolution of many herbivores with host plants that contain toxic secondary compounds means they have metabolic pathways easily adjusted to produce resistance (Croft and Strickler, 1983). In Sudan, the increasing application of pesticides to cotton over the past 50 years has steadily reduced the number of predator species. One insect, the whitefly, which was formerly kept in check by predators, is now an economically very important pest (Kiss and Meerman, 1991; PT, 1990).

Outbreaks and resurgences are more likely to occur when the landscape has been simplified to contain just a single crop. This may be of cereals, such as wheat or rice, or of plantation crops, such as bananas, cotton or coffee. In Costa Rica, 30 per cent of imported pesticides are used in the production of bananas for export. Bananas are grown in huge plantations, which are highly susceptible to pests and diseases, and there have been repeated cycles since the 1950s of heavy applications of one product, closely followed by pest outbreaks caused by the rapid development of resistance (Thrupp, 1990). When decisions were taken to stop spraying because of inefficiency and growing costs, insect pests rapidly declined: 'two years after insecticides were halted, the previous [predator] species became established again' (C Stephens in Thrupp, 1990). Today's integrated approach to pest management requires greater technical expertise and labour of managers and operators, and now incorporates cultural methods, minimal and selective use of insecticides, and threshold monitoring. Insects rarely now present any problems, though spraying against disease, nematodes and weeds is still heavy.

In Asia, where 90 per cent of the world's rice is produced and consumed, reports of disease and insect outbreaks are numerous (Khush, 1990; Kenmore, 1991; Winarto, 1994). Brown planthopper (*Nilaparvata lugens*, BPH) outbreaks have at various times destroyed hundreds of thousands of ha of rice in countries from India in the west to the Solomon Islands in the east. In Indonesia, the first problems started occurring in 1974. Losses jumped in 1975, after the government started subsidizing pesticides and in 1977 over 1 million tonnes of rice were lost, enough to feed some 2.5 million people (Kenmore, 1991). In 1979, 750,000ha were infested, followed by lower, but not insignificant, levels of infestation of between 20–150,000ha per year during the 1980s. During this period, BPH was only really checked with the release of rice varieties containing genes that confer resistance, though even some of these have been attacked by new biotypes of the pest (Khush, 1990).

Studies in the Philippines and Indonesia have clearly shown that outbreaks occurred after increases in insecticide use (Kenmore et al, 1984; Winarto, 1993). BPH is kept under complete biological control in intensified rice fields that are not treated by insecticides. Even with over 1000 reproducing adults per square metre, the natural enemies exert such massive mortality that rice yields are unaffected. As Peter Kenmore (1991) describes 'insecticide applications disrupt that natural control, survival increases by more than ten times, and compound interest expansion then leads to hundreds of times higher densities within the duration of one rice crop. Trying to control such a population outbreak with insecticides is like pouring kerosene on a house fire.' Other countries in South-East Asia still, however, suffer significant losses to BPH. In central Thailand, some 250,000ha were infested in 1990, the worst year on record.

Pesticides and Human Health Impacts

Mortality and morbidity from pesticides

There is no doubt that pesticides are hazardous. At very high dosages many are lethal both to laboratory animals and people, and can cause severe illness at sublethal levels. But just how serious is the hazard from medium to low dosages is open to question (Conway and Pretty, 1991; IARC, 1991). In the 1950s, 1960s and 1970s organochlorine insecticides were in widespread use in the industrialized countries and high levels of exposure were common in those engaged in their manufacture, in agricultural workers and, because of the presence of residues in foods, among the general public. Nevertheless, there is little evidence of serious ill health, other than as a result of accidental exposure to high dosages. The herbicides 2,4,5-T and 2,4-D were also commonly used in that period, and were originally thought to be a cause of miscarriages. Subsequent, more thorough, studies suggest a link with increased incidence of a certain rare cancer, non-Hodgkin's lymphoma, but not with miscarriages or other reproductive effects (Hoar et al, 1986, 1988; Witt, 1980; Agresti, 1979; Conway and Pretty, 1991).

Other pesticides appear to be intrinsically less hazardous, although the organophosphates, in particular, can cause severe poisoning. These are more acutely toxic than organochlorines but since they are not stored in body tissues are probably less hazardous over the long term. Two highly hazardous pesticides are the nematocide, DBCP, which causes infertility in humans and the herbicide, paraquat, which is carcinogenic and mutagenic. However, many synthetic pyrethroids, and modern herbicides and fungicides, have very low toxicity and no known health effects.

In the industrialized countries, the major hazard lies in accidents. Even then, fatalities at work are very rare – one a decade in the UK and eight a decade in California – and there are many other more common causes of death on the farm. There is, though, a relatively high incidence of ill health among those engaged in applying pesticides. Farmers exposed to organophosphates during the dipping of sheep, for example, appear increasingly to be suffering a wide range of sub-acute health problems.

One problem is that the systems for recording pesticide poisoning vary within and between countries, and are difficult to compare. In the UK, there are at least four institutions collecting mortality and morbidity data, all giving different data (Conway and Pretty, 1991; HSE, 1993). These suggest some 40–80 confirmed cases each year. In California, a comprehensive system of reporting, perhaps the best in the world, records some 1200–2000 cases each year (CFDA, passim). Overall the hazard in the industrialized countries presented by pesticides appears to be not very different from that of other manufactured chemicals, such as pharmaceuticals.

By far the greatest risk, though, is from pesticides in the home and garden where children are most likely to suffer. In California alone, some 6–8000 children of less than six years of age are treated for pesticide poisoning each year. In Britain, some 600–1000 people need hospital treatment each year from home poisoning (Conway and Pretty, 1991). Although, in this respect, pesticides are no different from hazardous medicines, they are often not perceived as being in the same category and are less carefully guarded. Nonetheless, there continues to be considerable public concern over the risks arising from exposure to pesticides, in particular through accidental spraying and spray drift, or from residues in foodstuffs.

Greater hazards in developing world countries

In developing world countries, mortality and illness due to pesticides are much more common relative to the amount of pesticide used. Lack of legislation, widespread misunderstanding of the hazards involved, poor labelling and the discomfort of wearing full protective clothing in hot climates, all greatly increase the hazard both to agricultural workers and to the general public (Conway and Pretty, 1991). Moreover, many pesticides known to be highly hazardous and either banned or severely restricted in the industrialized countries, such as parathion, mevinphos and endrin, are widely available. In 1988, the Food and Drug Administration of the US found that 5 per cent of some 10,000 imported foods when tested were found to contain residues of products banned in the US, indicating continued widespread export and use of such compounds (GAO, 1989).

It is very difficult to say how many people in the South are affected by pesticide poisoning. This is partly because reporting mechanisms are weak, with farmers tending not to seek medical treatment – as is also the case in the North (Dinham, 1993). Most data are gathered by doctors, researchers and activists from individual testimony and hospital records, and so are viewed as anecdotal or circumstantial. This is not to denigrate these reports; it is just that many policy makers do not accept them as sufficiently 'scientific'.

Nonetheless, put together, the data paint a picture more bleak than appeared to be the case in the 1980s (Conway and Pretty, 1991; Dinham, 1993).

- In Malaysia and Sri Lanka, for example, some 7–50 per cent of all farmers reported that they experienced poisoning at least once in their lives (Jeyeratnam, 1990).
- In Thailand, a survey of 250 government hospitals and health centres revealed that some 5500 people were admitted for pesticide poisoning in 1985 alone, of whom 384 died (Jonjuabsong and Hwai-kham, 1991).
- In Latin America, between 10–30 per cent of agricultural workers tested show inhibition of the blood enzyme, cholinesterase, which is a sign of organophosphate poisoning (WHO, 1990).
- In Venezuela, there were 10,300 cases of poisoning with 576 deaths, between 1980–90 (Dinham, 1993).
- In Paraguay, 75 per cent of farmers around Asunción experienced symptoms after spraying (Dinham, 1993).
- In Brazil, 28 per cent of farmers in Santa Catarina say they have been poisoned at least once; and in Parana, some 7800 people were poisoned between 1982–1992 (Dinham, 1993).
- In China, a recent statement from the Agricultural Ministry in China suggested that more than 10,000 Chinese farmers died in 1993 from poisoning by pesticides (Quinn, 1994). Many were said to be victims of home-made cocktails marketed illegally and some 30 per cent of products were unlicensed by authorities. Since 1975, the value of pesticide imports into China has grown from US$76 million to $293 million.

According to the latest (1990) estimates by the WHO, a minimum of 3 million and perhaps as many as 25 million agricultural workers are poisoned each year, with perhaps 20,000 deaths.

Pesticide poisoning and health costs in the Philippines

Recent evidence emerging from the intensive rice-growing regions of the Philippines is confirming this picture of common mortality and illness from pesticides. These areas have greatly benefited from the Green Revolution packages and use of pesticides is still growing, with sales of pesticides increasing by 70 per cent between 1988 and 1992. Between 1980–1987, the National Department of Health Statistics recorded some 4031 cases of pesticide poisoning, including 603 deaths (Casteñeda and Rola, 1990). But this may be an underestimate of the extent of poisoning, as studies are increasingly showing high incidence of poisoning symptoms that go unreported by farmers (Rola and Pingali, 1993; Marquez et al, 1992; Rola, 1989; Loevinsohn, 1987). A recent WHO report recorded 1303 cases of poisoning between January 1992 and March 1993 in one region alone (WHO, 1993).

In one study, Michael Loevinsohn (1987) examined mortality statistics in several contrasting municipalities in central Luzon for diagnosed pesticide poisoning and for other conditions that could be the result of such poisoning. Organochlorines such as endrin and HCH can cause convulsions, so that poisoning may be misdiagnosed as epilepsy, brain tumours or strokes. Similarly, poisoning by organophosphates, such as parathion, can be misdiagnosed as cardiovascular or respiratory diseases.

The study detected a 27 per cent increase between 1961–1971 and 1972–1984 of non-traumatic mortality rates among rural males aged 15–54 years, although in children and women it decreased. This increase closely coincided with the growth in pesticide use. When the figures were broken down, they revealed that deaths in the rural areas diagnosed as poisoning increased by 247 per cent and those from associated conditions by 41 per cent between the two periods, yet mortality from all other causes, except cancer, decreased by 34 per cent. In the case of stroke, mortality increased for all men in both the urban and rural areas, but significantly the increase was greater among young men who are generally at low risk of stroke.

Following the 1982 ban on endrin, mortality attributed to stroke decreased for all men, but the decrease was significantly greater among the younger men in rural areas. The study also revealed that mortality rates had originally peaked each year during August, the month of greatest insecticide use. But after double-cropping became widespread, a second mortality peak appeared in February, at a time when insecticides were used on the newly cultivated dry season crops. These correlations are highly suggestive of occupational exposure to pesticides.

Another important study compared the health status of farmers exposed to pesticides in Nueva Ecija with those unexposed in Quezon. In the exposed group, there were statistically significant increased eye, skin and lung problems. Some 67 per cent of farmers suffered from severe irritation of the conjunctivae (compared with 10 per cent in the unexposed group); 46 per cent suffered from eczema and nail pitting (compared with none in the unexposed); and 46 per cent suffered respiratory problems (compared with 23 per cent in the unexposed). Another study of Nueva Ecija farmers found that 50 per cent of rice farmers suffered from sickness due to pesticide use (Rola, 1989).

Agnes Rola of the University of the Philippines and Prabhu Pingali of IRRI (1993) calculated the health costs of these pesticide problems, taking into account impact on exposed farmers and the costs of restoring individuals to normal health, so as to examine the economics of various pest control strategies. The 'complete protection' strategy, in which some nine sprays are used per season, returned less per hectare than the economic threshold, farmers' practice and natural control strategies (Table 1.3). These results indicate that both farmers and the national economy at large would be better off by cutting pesticide use or eliminating it entirely by adopting more integrated and sustainable practices.

Table 1.3 *Net benefit and health costs of four pest management strategies in lowland irrigated rice, Philippines*

Pest management strategy	*Net benefits, excluding health costs (Pesos/ha)*	*Health costs (Pesos/ha)*
Complete protection: nine applications of pesticide per season	11,846	7500
Economic threshold: treatment only when threshold passed, usually no more than two applications used	12,797	1188
Natural control: pest control emphasizes predator preservation and habitat management, alternative hosts and resistant varieties	14,009	0
Current local practice: 2–3 applications of very hazardous compounds per season	13,847	720

Source: Rola and Pingali, 1993

Soil Conservation and Erosion

The causes and costs of erosion

Despite the fact that indigenous systems of soil and water conservation are widespread, well adapted to local conditions, persist for long periods and are capable of supporting dense populations, soil erosion continues to be a problem throughout the world (UNEP, 1983; Reij, 1991; Kerr and Sanghi, 1992; Tato and Hurni, 1992; Hudson and Cheatle, 1993; Pretty and Shah, 1994). Indigenous systems are insufficient alone to prevent agricultural land from continuing to lose productive soil, water and nutrient resources. This is partly because not all farmland is protected by conservation measures, but also because not all erosion arises from farmland. Both roads and urban areas concentrate water flows and non-agricultural areas are also subject to erosion.

Farmers may not be conserving soil and water for a variety of reasons. They may lack the locally appropriate knowledge or skills, particularly if they have been resettled or migrated to new areas. They may be unwilling to invest in conservation measures if the economic costs of conservation are greater than the expected benefits, particularly if the future is uncertain, such as if political instability or conflict threaten the future, or if security of tenure is uncertain. Farmers may be short of labour for construction or maintenance, such as following a decline in population, outmigration in the face of better opportunities for income earning, particularly in urban centres, or simply rising labour costs. They may not be conserving because of the misguided efforts of earlier soil and water conservation programmes. Finally, they may be so responsive to policies encouraging increased food production that they simply ignore the costs.

In Britain, a major cause of soil erosion has been the shift in recent years towards the cultivation of winter cereals, driven by production-oriented policies. The high price of wheat has encouraged winter cultivation in fragile environments and this has led to a massive increase in soil erosion. It was long thought that water erosion was not a problem for British agriculture. But, since the late 1960s, the land sown to winter cereals has tripled, largely at the expense of grassland and spring cereals. Erosion can be of the order of 30–95t/ha in fields where field boundaries and hedges have been removed from critical positions. Bob Evans estimates that some 6200km^2 (4.4 per cent) of land in Britain is now at high risk and some 2100km^2 (1.5 per cent) at very high risk. Erosion is greatest when there is little vegetative cover, such as during winter when winter cereals are being grown; when slopes are long, such as in big fields; and when farmers cultivate up and down slopes, rather than across the contour (Evans, 1990a, 1990b).

On the South Downs in England, for example, erosion was uncommon until winter cereals were widely grown. In the late 1970s, only 5 per cent of these chalk downs were under winter cereals, but this increased to 65 per cent by 1992. In the past ten years, loss of soil accompanied by flooding has caused many incidents of flooding of housing and farms, causing several hundred thousand pounds worth of damage (Boardman, 1990, 1991; Boardman and Evans, 1991; Robinson and Blackman, 1990).

To farmers, erosion reduces the biological productivity of soils and the capacity to sustain productivity into the future. Although soil erosion is clearly costly to economies as well as to farmers, it is difficult to calculate reliably the precise costs (Eaton, 1993; Bishop, 1990). Studies in Mali, Malawi and Java suggest that the costs to farmers are substantial, representing 3–14 per cent of gross agricultural product (Table 1.4).

Off-site costs are also important. Soils are less able to retain water, which runs off more readily into waterways carrying sediments. These block downstream irrigation canals, reservoirs and harbours. Reduced volume means both greater maximum flows and so more likelihood of floods, and reduced minimum flows in dry seasons. The functional lifetime of reservoirs has declined in many countries. And natural systems, particularly fisheries and coral reefs, are threatened by sediments and agricultural pollutants.

In Java, sedimentation costs the economy US$25–90 million each year by shortening the life of reservoirs, reducing hydroelectric output, and increasing maintenance needs for dredging irrigation systems and harbours. In Thailand, a steadily depleting capacity of 20 reservoirs costs US$0.3 million in forgone income from reduced irrigation capacity and in lost hydroelectric capacity. Greater costs, some $18 million annually, are incurred by the need to dredge 19 million m^3 of sediment from the Chao Phraya River to keep the channel open to shipping. These off-site costs can be substantially greater than the financial losses to farmers. At one site in the UK, where soil loss reached 250t/ha, the estimated total loss to the farmers was just £13,000, mostly due to lost seed and fertilizer, compared with £400,000 of damage to housing (Robinson and Blackman, 1990).

Table 1.4 *Selection of the on- and off-site costs of soil erosion*

On-site costs	
Mali (1988)	US$4.6–18.7 million per year Equivalent to 3–13 per cent of agricultural GDP and 1.7 per cent total GDP
Malawi (1980s)	US$25 million per year Equivalent to 14.6 per cent of agricultural GDP and 4.8 per cent total GDP
Java, Indonesia (1980s)	US$320 million per year Equivalent to 3 per cent of agricultural GDP
Off-site costs	
US (1990)	US$10,150 million of damage to freshwater and marine recreation, to water storage, navigation, flooding, fishing, water treatment, irrigation channels, roadside ditches and steam cooling
Cape Verde (1984)	US$2.6 million from a single storm
Java (1980s)	US$25–90 million per year for sedimentation
Thailand (1980s)	US$18 million per year for sedimentation
UK (1982–87):	
Mile Oak, Sussex	£105,000 of damage to housing, plus £150,000 on flood alleviation works
Rottingdean, Sussex	£400,000 of damage to 40 houses, gardens and roads
Breaky Bottom, Sussex	£81,000 of damage to vineyard

Sources: Ribaudo, 1989; Boardman and Evans, 1991; Bishop, 1990; Bishop and Allen, 1989; Attaviroj, 1991; Haagsma, 1990; Magrath and Arens, 1989; Faeth et al, 1991; Robinson and Blackman, 1990

More terracing and more erosion

Despite decades of effort, soil and water conservation programmes have had surprisingly little success in preventing erosion. The quantitative achievements of some programmes can appear impressive. In Lesotho, all the uplands were said to be protected by buffer stripping by 1960; in Malawi (then Nyasaland), 118,000km of bunds were constructed on 416,000ha between 1945–1960; and in Zambia (then North Rhodesia), half the native land in eastern province was said to be protected by contour strips by 1950 (Stocking, 1985). In Ethiopia, during the late 1970s and 1980s, some 200,000km of terracing were constructed and 45 million trees planted (Mitchell, 1987).

Ironically, though, many programmes have actually increased the amount of soil eroding from farms. This is because these impressive achievements have mostly been short lived. Because of a lack of consultation and participation, local people, whose land is being rehabilitated, find themselves participating for no other reason than to receive food or cash. Seldom are the structures maintained, so conservation works rapidly deteriorate, accelerating erosion instead of reducing it. If performance is measured over long periods, the results have been extraordinarily poor for the amount of effort and money expended (Shaxson et al, 1989; Hudson, 1991; Reij, 1991).

It is well established that poorly designed structures cause erosion. Yet throughout Africa, little account has been taken of how more terracing can lead to more erosion. In the early 20th century, erosion in Lesotho was not a serious problem in cultivated fields, because grassed field boundaries were well developed and maintained (Showers, 1989). Despite this indigenous practice, contour banks were installed. Local people did not approve, because they reduced the size of fields, and either breached or the outlets developed into gullies. The administration attributed these gullies to *'unusual weather'* (Showers and Malahleha, 1990). Elsewhere in southern Africa, the first anti-erosion measures introduced in the early 1930s were large ridge terraces and bunds. But these imported measures disturbed natural patterns of drainage and permitted storm water to break through at vulnerable points. Careless construction made them susceptible to bursting and locals came to believe that 'gully erosion was caused by the government' (Beinart, 1984).

Narrow-based terraces were introduced into Kenya from the US in 1940 (Gichuki, 1991). For 15 years they were widely used. By 1947, some 4000 hectares were being protected each year and this rate continued until 1956–1957. But these terraces filled up with sediments too quickly, were impossible to maintain and even began to aggravate erosion. And so, by 1958, the number falling into disrepair was exceeding new construction. By 1961, some 20,000ha had fallen into disrepair. Eventually, the authorities recognized the problems and L. H. Brown, the chief agriculturalist, issued a memorandum in 1961 saying that 'narrow-based terraces should be abandoned as policy... we should move to strips of vegetation, preferably grass' (in Wenner, 1992).

Bad contour ridging in the 1960s was worse than none at all in Zimbabwe (then Rhodesia), where farmers say the compulsory construction of ridges caused siltation of rivers. The ridges connected whole fields and drained in a single drainage line, so during large storms, concentrated water into powerful and fast-moving bodies that caused great damage (Wilson, 1989). The same thing has occurred with cut-off drains in Kenya. Their function is to intercept and divert storm water, but many were constructed in a way that caused erosion. 'The most severe mistakes were that cut-off drains were laid and constructed on the wrong sites. They were designed with steep gradients... The water is discharged into gullies which are deepening. The channel ridges were bare and cut-off drains were not supported by other structures below them... All these factors have made the structures more dangerous than useful. More problems were created. Gullies have widened, soil was eroded and crops destroyed' (Hunegnaw, 1987).

Recent project efforts

Graded and contour bunds developed for large-scale farming in the US are widely applied in soil and water conservation programmes in India. Even under heavy subsidies, most small farmers reject them, for very good reasons (Kerr and Sanghi, 1992). These bunds leave corners in some fields and so there is a risk of losing the piece of land to a neighbour. The central water course for drainage benefits only some farmers, damaging the land of others. Contour farming is inconvenient when farmers use multi-row implements, and so is only suitable where the holding is large and tractors are available. Contour bunding without facilities for dealing with surplus water commonly breach, again concentrating water flow that quickly forms gullies. It is, therefore, not uncommon for entire bunds to be levelled as soon as project staff shift to the next village (Sanghi, 1987).

Sometimes, successes are reversed almost immediately. In an evaluation of World Food Programme supported conservation in Ethiopia, the extent of the terracing was said to be 'impressive', yet monitoring in one sub-catchment found 40 per cent of the terracing broken the year after construction (SIDA, 1984). The project had expected that local people would bear all the costs of maintenance. Another example comes from the Yatenga region of Burkina Faso, where 120,000ha of earth bunds constructed at high cost with machine graders in the early 1960s have now all but disappeared (Marchal, 1978, 1986). In the Majjia and Badéguicheri valleys of Niger, most of the 6000ha of earth bunds constructed between 1964–1980 are in an advanced state of degradation (Reij, 1988). In Sukumuland, Tanzania, where contour banks, terraces and hedges were forced upon farmers, almost no evidence remained of these conservation works by the early 1980s and now 'erosion is extremely severe' (Stocking, 1985).

In Oaxaca, Mexico, a large-scale government soil conservation programme is also establishing contour bunds based on the US models. It is an area noted in the 1970s and 1980s by various 'expert' missions as having 'massive soil erosion' and 'the world's worst soil erosion'. But recent evidence is suggesting that erosion has only become serious following the imposing of terraces and bunds (Blackler, 1994). Rill erosion has been recorded within one year of their establishment and degradation has been so severe that less than 5 per cent of the bunded area is cropped.

In Cape Verde off the west coast of Africa, the state takes responsibility for erosion control by paying farmers to work on their own land. The result is that traditional practices are ignored as farmers take the money without influencing the project. *Socalco* terraces, for example, are built from top to bottom of steep slopes, with the result that foundations are often left hanging in the air (Haagsma, 1990). As Ben Haagsma has put it 'this does not stimulate … good cooperation between farmers and MDRP [the project]. It is difficult to eradicate the attitude "MDRP knows best".' In India, farmers have only permitted bunds to be constructed on their fields because they are attracted to subsidies. The impact on the relations between government and farmers is serious: 'in most villages farmers have become addicted to subsidies which normally come as part of development projects.' (Sanghi, 1987).

The impact of these programmes has been to make many things worse. A failure to involve people in design and maintenance can create considerable long-term social impact. The enforced terracing and destocking in Kenya, coupled with the use of soil conservation as a punishment for those supporting the campaign for independence, helped to focus the opposition against both authority and soil conservation (Pretty and Shah, 1994; Gichuki, 1991). This led, after independence, to the deliberate destruction of many structures because of their association with the former administration (Anderson, 1984). In neighbouring Somalia, a large Food and Agriculture Organization (FAO)-funded project constructed dams during the 1970s to check gullies, but because of poor construction, many collapsed or diverted the floods, so accelerating gully erosion instead of preventing it. This induced widespread disenchantment amongst local people for all conservation projects that followed (Reij, 1988). Such attitudes are a critical constraint for many current soil conservation programmes.

The Loss of Biodiversity

Why farmers prefer diversity

Farmers of traditional and low input agricultural systems have long favoured diversity on the farm. Today, there is still a huge variety of mixtures cultivated, including cereals, legumes, root crops, vegetables and tree crops. In Africa more than 80 per cent of all cereals are intercropped, producing in some cases highly complex patterns on the ground, with up to 20 species grown in close proximity (Vandermeer, 1989; OTA, 1988). In Latin America, about 60 per cent of maize is intercropped and 80–90 per cent of beans are grown with maize, potatoes or other crops (Francis, 1986). In one field in the Andes in Peru, Robert Rhoades recorded some 36 potato varieties growing in 13 rows (Rhoades, 1984). These were all shapes and sizes, and a variety of colours, including black, red, blue, purple, yellow and white. Altogether some 3000 traditional varieties are still grown by Andean farmers.

In very variable conditions, farmers rarely standardize their practices. They maintain diversity, develop a variety of strategies and so spread risk. Mixtures of crops and varieties clearly provide farmers with a range of outputs, and also represent logical approaches to coping with variable environments. Mixed crops can also be less variable in time and space, and combined yields are often greater, particularly if differences in root and shoot geometry allow the crops to use light, nutrients and water more efficiently (Vandermeer, 1989; Francis, 1986; Rao and Willey, 1980; Trenbath, 1974). Intercropping can reduce weed problems, so influence labour requirements; returns to labour can be increased; and erosion and runoff may be reduced by the greater ground cover given by the mixture (OTA, 1988).

Farmers themselves recognize the value of mixtures. In Indonesia, farmers in rainfed conditions plant a greater mix of crop combinations during the more risky seasons (Castillo, 1992). In the dry season, they plant 42 combinations; in the uncertain middle season, they use 25; and in the rainy season, they plant just 7. The author of a recent comprehensive review of intercropping, John Vandermeer, has put it: 'In personal conversation with [farmers] in southern Mexico, Costa Rica and Nicaragua, I have frequently … been told that two crops make a good combination because one is taller than the other and "fits in" to the spaces where the other does not, or that the root systems go to different depths and thus use nutrients from different parts of the soil.' Such popular knowledge is common.

It is, however, impossible to say categorically whether a mixture will result in better yields than the monocropped alternatives, except perhaps for legume–non-legume mixtures (Trenbath, 1976; Willey, 1979; Vandermeer, 1989). Much depends upon the local conditions and characteristics of the crops themselves. Pest attack is frequently reduced in intercrops, because of a variety of factors (Risch et al, 1983). Host plants are more widely spread and so harder to find; one species may trap a pest; or one species may repel the pest; and/or predators may be attracted. Weeds are also more likely to be suppressed by mixtures.

Recent surveys of non-irrigated rice systems in Cambodia, Indonesia, Laos, Madagascar, Myanmar, Nepal, Philippines and Thailand have found that farmers manage their highly diverse conditions with different land use strategies (Fujisaka, 1990, 1991; Fujisaka et al, 1992). Farmers described different combinations of landscape position, soil type, hydrology, and flood and drought risk, and showed how they matched these to different combinations of rice varieties and management practices. In upland Laos, for example, farmers distinguished 20 different types of soil. Each grew up to four varieties of rice, with 29 varieties grown in the two regions of Luang Prabang and Oudomasay. But these mixes are not static. Farmers are continually experimenting with new varieties or readopting old or existing ones. In Bukidnon, Philippines, farmers were cultivating 18 varieties, having dropped another six in recent years.

In Myanmar, 52 different varieties of rice were encountered in rainfed uplands and lowlands, and in deepwater conditions. Each farmer does not seek to maximize yield, nor do they have one preferred variety. They grow up to six varieties each, with a range of different taste, colour, pest resistance, growth pattern, duration, flood/drought tolerance, milling recovery and market price qualities (Table 1.5).

The decline under modernization

It is only recently that fields monocropped to single species and varieties have become common. The introduction of modern varieties and breeds has almost always displaced traditional varieties and breeds. During the 20th century, some 75 per cent of the genetic diversity of agricultural crops has been lost. Only about 150 plant species are now cultivated, of which just three supply almost 60 per cent

Table 1.5 *Numbers of rice varieties and their qualities encountered in three non-irrigated rice regions of Myanmar*

Region	*Number of varieties*	*Qualities of rice varieties*
Rainfed uplands	18	115 to 180-day duration red and white glutinous and sticky long and short awned and awnless drought tolerant and intolerant 100–150cm in height for eating or for rice wine grain size length of time in stomach yields from 1.0 to 2.0t/ha
Deepwater rice	18	elongation from water panicle in or out of water expansion when cooked eating quality yellow and white resistance to stem borer yield from 1.5 to 1.8t/ha
Rainfed lowlands	16	125–200 day duration flood or drought tolerant glutinous or not yellow, white or black length of time in stomach fertilizer responsiveness distinctive aroma expansion when cooked yields from 1.2 to 6.2t/ha

Source: Fujisaka et al, 1992

of calories derived from plants (FAO, 1993; Fowler and Mooney, 1990). The trend has been rapidly downwards in many countries (Table 1.6). In India, once more than 30,000 rice varieties were grown, but now just 10 cover 75 per cent of the whole rice area. A comprehensive study of the decline in the US this century has been conducted by Cary Fowler and Pat Mooney (1990), where 'the losses of fruit and vegetable varieties are staggering'. For 65 types of vegetable, they record a consistent loss of between 80–100 per cent of the varieties of each since the turn of the century. Of the 8207 varieties listed for these vegetables in 1903, only 607 are now held by the National Seed Storage Laboratory.

Most modern scientists have seen mixtures as a problem to be overcome. When the Rockefeller-sponsored team first visited Mexico in the 1940s to assess wheat cultivation as a precursor to establishing the national wheat breeding programme, the low-yielding traditional fields were condemned because: 'most fields were a mix of many different types, tall and short, bearded and beardless, early ripening and

Table 1.6 *Decline in diversity of crops and livestock in a selection of locations*

India	Once more than 30,000 rice varieties grown; now expected that just 10 rice varieties will soon cover 75 per cent of rice area.
Philippines	Before the modernization of early 1970s, 3500 varieties of rice existed; now only 3–5 are grown in irrigated areas.
Europe	Half of all the breeds of domestic animals (horses, cattle, sheep, goats, pigs and poultry) have become extinct since the beginning of the 20th century; a third of the remaining 770 breeds are in danger of disappearing by 2010.
France	71 per cent of apple production from one variety, Golden Delicious; 30 per cent of bread wheat from 2 varieties and 70 per cent from 10 varieties; In the SE, the Provençal diet contained 250 plant species at beginning of 20th century; now it comprises only 30–60.
Greece	95 per cent of local wheat varieties lost since 1920s.
The Netherlands	A single potato variety covers 80 per cent of potato land; 90 per cent of wheat planted to 3 varieties; 75 per cent of barley planted to 1 variety.
UK	68 per cent of early potatoes planted to 3 varieties; 4 wheat varieties account for 71 per cent of wheat area.
US	Since 1900: 6121 apple varieties lost (85 per cent) 2354 pear varieties lost (88 per cent) 546 garden pea varieties lost (95 per cent) 516 cabbage varieties lost (95 per cent) 394 field maize varieties lost (91 per cent) 383 pea varieties lost (94 per cent) 329 tomato varieties lost (81 per cent) 295 sweet corn varieties lost (96 per cent) Now: 71 per cent maize area planted to 6 varieties 96 per cent pea area planted to 2 varieties 65 per cent rice area planted to 4 varieties 76 per cent snap bean area planted to 3 varieties

Sources: Pimbert, 1993; FAO, 1993; Soetomo, 1992; Fowler and Mooney, 1990

late ripening; fields usually ripened so unevenly that it was impossible to harvest them at one time without losing too much over-ripe grain or including too much under-ripe grain in the harvest' (Stakman et al, 1967). These mixtures of traditional varieties may not have yielded well, but did give some insurance against pest and disease attack. Modern wheat varieties introduced in Mexico in the 1940s and 1950s were soon susceptible to new races of rust, and were quickly overcome.

Similar simplification occurred during rice modernization in Asia. In Central Luzon, Philippines, for example, all 25 varieties grown by farmers in the mid-1960s were traditional varieties. By 1980, the total number of varieties grown had fallen only to 19, but just two were traditional (Cordova et al, 1981). Some 95 per cent of the rice area is now planted to modern varieties. In the US, mixtures of wheat and oats, oats and barley, sorghum and alfalfa, maize and soybean were common in the early part of this century (Thatcher, 1925; Bussell, 1937; Bailey, 1914). All these are now mainly grown as monocrops. Mostly it has been the incentive structures provided by cheap and available inputs that has encouraged farmers to specialize. But in some countries, farmers have been prevented by law from growing traditional varieties and there have been reports of traditional crops being burned or destroyed (Soetrisno, 1982).

With these losses of genetic diversity could go future opportunities. Locally adapted crops or livestock can be critical for helping to deal with particular challenges brought by pests or diseases. One rice variety from India, for example, has been central to efforts to cope with a devastating virus. During the 1970s, the grassy-stunt virus devastated rice from India to Indonesia. After a four-year search, in which over 17,000 cultivated and wild rice samples were screened, disease resistance was found. One population of the wild species, *Oryza nivara*, growing near Gonda in Uttar Pradesh, was found to have a single gene for resistance to grassy-stunt virus strain 1. Today, resistant rice hybrids containing the wild Indian gene are grown across some 110,000km^2 of Asian rice fields (FAO, 1993). Genetic erosion, the reduction of diversity within a species, is a global threat to agriculture.

The value of wild diversity

The value of wild biodiversity to farming households has seldom been recognized by agriculturalists (Jodha, 1990; Bromley and Cernea, 1989; Scoones et al, 1992). Wild resources are often called wastes or wastelands, and represent a symbol of backwardness and underdevelopment. During the British agricultural revolution of the 17th to 19th centuries, common resources were seen by many officials as the 'trifling fruits of overstocked and ill-kept lands' (in Humphries, 1990), and 'mere sand … and fit for nothing but rabbits' (Burrell, 1960); and to large landowners, commons 'burdened a village with beggarly cottages and idle people. They were better enclosed [for agriculture]' (in Thirsk, 1985). In India, common resources are still called wastelands.

It is well recognized that hunter–gathering communities, such as the !Kung San in Botswana or Indian groups in the Amazon, depend on wild resources for their complete livelihoods. What is less widely recognized is that farming households also rely heavily on wild resources (Table 1.7). If wild habitats are lost, these resources will no longer be available to rural households. And those who will suffer most are the poorest, who most often rely on wild resources as key sources of food, fuel, medicines and fodder.

Many agricultural institutions were indicating during the 1980s that agricultural area would have to expand substantially if growing world populations would be fed (TAC, 1988). More recently, these calls have been toned down, as it is being increasingly recognized that expansion on this scale will incur significant costs to rural households and national economies alike.

Table 1.7 *Use of wild plants for food and medicine by farming communities*

Location	*Importance of wild resources*
Brazil[1]	Kernels of babbasu palm provide 25 per cent of household income for 300,000 families in Maranhâo State
China, West Sichuan[2]	1320 tonnes of wild pepper production; 2000t fungi collected and sold; 500t ferns collected and sold
Ghana[3]	16–20 per cent of food supply from wild animals and plants
India, West Bengal[4]	155 wild plants collected for food, fodder, medicine and fuel
Kenya, Bungoma[5]	100 species wild plants collected; 47 per cent of households collected plants from the wild and 49 per cent maintained wild species within their farms to domesticate certain species
Kenya, Machakos[6]	120 medicinal plants used, plus many wild foods
Nigeria, near Oban National Park[7]	150 species of wild food plants
South Africa, Natal/KwaZulu[8]	400 indigenous medicinal plants are sold in the area
Sub-saharan Africa[9]	60 wild grass species in desert, savanna and swamp lands utilized as food
Swaziland[10]	200 species collected for food
Thailand, NE[11]	50 per cent of all foods consumed are wild foods from paddy fields, including fish, snakes, insects, mushrooms, fruit and vegetables
South west of US[12]	375 plant species used by native Indians
Zaire[13]	20 tonnes chanterelle mushrooms collected and consumed by people of Upper Shaba
Zimbabwe[14]	20 wild vegetables, 42 wild fruits, 29 insects, 4 edible grasses and one wild finger millet; tree fruits in dry season provide 25 per cent of poor people's diet

Sources: 1 Fowler and Mooney, 1990; 2 Zhaoqung and Ning, 1992; 3 Dei, 1989; 4 SPWD, 1992; 5 Juma, 1989; 6 Wanjohi, 1987; 7 Okafor, 1989; 8 Cunningham, 1990; 9 Harlan, 1989; 10 Ogle and Grivetti, 1985; 11, 12, 13 Scoones et al, 1992; 14 Wilson, 1989

Recent responses to support farmers

When external agencies work closely with farmers to document the variety and performance of their crops, the results can be extraordinary (Salazar, 1992; Fowler and Mooney, 1990). Many have found varieties that perform well in low external input conditions (Box 1.1). The Phrey Phdau rice research station in Cambodia, for example, has collected 1320 local rice varieties with the help of Oxfam. One local variety, *2-Somrung 2*, yields 5t/ha under low-external input conditions. Another, Prambei Khor, compares equally with IR42 on yield terms, and has superior straw production and grain quality. In Thailand, the non-governmental organization (NGO) Technology for Rural and Ecological Enrichment (TREE) has collected

Box 1.1 *The role of the group 'Farmer-Scientist Participation for Development' (MASIPAG), Philippines in the conservation of biodiversity*

The MASIPAG programme was established in 1986 to encourage farmers' participation in the development of improved varieties which yield well under low-external input conditions. The programme has:

- collected 210 accessions from farmers around the country;
- made cross-combinations to produce 101 selected lines by 1990; of these half showed good yield potential under low input conditions;
- distributed 40,000kg of seed selected from 34 cultivars around the country;
- produced varieties that yield 3.7–5.7t/ha with no applications of fertilizer or pesticides; this compares with a range for MVs needing external inputs of 3.2–5.2t/ha.

Source: Salazar, 1992

4000 accessions of rice in two years, which have been stored in the National Rice Germplasm Bank pending the development of community seed banks (Salazar, 1992; Siripatra and Lianchamroon, 1992).

Once again, the clear principle is that farmers, given the choice, rarely replace local varieties entirely with a single MV. They prefer to add a MV to their existing mix of options. In Indonesia, a local variety called *Rojolele* was found that compared well with IR64, a recent release from International Rice Research Institute (IRRI) (Soetomo, 1992). IR64 yields better but, because it needs more water, weeding and fertilizer, it gives lower returns to farmers. *Rojolele* is also favoured for its distinctive taste and fragrance, as well as being fairly resistant to brown planthopper, rats and birds, unlike IR64. Farmers can also produce it locally in community seed banks, which are growing in popularity in Indonesia, despite them being contrary to existing government policy that holds that germplasm should be managed only in official genebanks.

When farmers are given the choice about new varieties, they much prefer to absorb the new technology into their existing systems. This is quite different to the way that agricultural modernization has worked so far, with farmers having to adopt the whole package or nothing at all. Recent participatory research with women farmers in Andhra Pradesh conducted by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) scientists led by Michel Pimbert has shown how important is the principle of supporting local biodiversity. Women experimented with new varieties of pigeonpea that were resistant to the pod borer, *Helicoverpa armigera*, which can devastate whole crops in bad years (Pimbert, 1991). Although some varieties were rejected because of bitter taste, interest was generated by the resistance to pod borer. Women farmers, though, said they would not replace their traditional varieties, but incorporate the new varieties of pigeonpea into their current mix of landraces. The new technology, in this case, has been adapted to suit local farming and livelihood conditions.

The Breakdown of the Social Fabric of Rural Communities

The social costs of modernized agriculture have been widely documented. As agriculture has increasingly substituted external inputs and resources for internal ones, so there has been a decline in the number of jobs for local people. Standardization has reduced the range of management skills needed, and many decisions have been taken out of the hands of farmers and local institutions.

Agricultural modernization has helped to transform many rural communities in both industrialized and developing world countries. The loss of jobs, the further shift of economic opportunity away from women to men, the increasing specialization of livelihoods, the increasing concentration of land in the hands of wealthy villagers and urban investors, the growing gap between the well-off and the poor, and the co-option of village institutions for the purposes of the state, have all been features of this transformation.

Social change in rural Britain

A period of remarkably successful agricultural growth since the mid-20th century has brought significant social change in rural areas of Britain (see, e.g. Newby, 1980). As farming has intensified its use of external inputs, so it has shed jobs, bringing poverty and deprivation to many people. Between 1945 and 1992, the number of farms in England and Wales has fallen from 363,000 to 184,000, while the total area of agricultural land has remained stable at 19 million ha. Over the same period, the number of regular hired and family workers on farms in England alone fell from 478,000 to 135,000 (MAFF, passim). In the past decade, there have been dramatic falls in the numbers of most types of people engaged in farming activities throughout Britain (Table 1.8). It is expected that the number of people

Table 1.8 *Changes in labour force (in thousands) on agricultural holdings in the UK, 1981–92*

Class of worker engaged agriculture	*1981*	*1992*
Total labour force (in thousands)	709.9	621.8
Total farmers, partners, directors	293.6	280.5
Spouses of farmers, partners and directors doing farm work	74.6	76.0
Salaried managers	7.9	7.8
Regular hired whole and part-time workers	182.2	124.9
Regular family workers	54.5	46.4
Seasonal or casual workers	97.0	86.2

Source: Pretty and Howes, 1993, using MAFF Agricultural Statistics from Agricultural and Horticultural Censuses, prepared by Government Statistical Service, Guildford engaged in agriculture will fall by a further 17–26 per cent during the 1990s (in DoW, 1992). Now, as a result of modernization, some of the worst poverty is in rural areas (Pretty and Howes, 1993).

In the quest for greater food production, landscapes have been homogenized, and rural livelihoods and farming systems have been progressively simplified. Where there were diverse and integrated farms employing local people, there are now operations specializing in one or two enterprises that largely rely on farm or contractor labour only. Where processing operations were local, now they are centralized and remote from rural people. The result is that few people who live in rural areas have a direct link to the process of farming. Fewer people make a living from the land and, of course, they understand it less. The lack of employment has also coincided with the steady decline in rural services, such as schools, shops, doctors and public transport.

However, the number of people in rural areas is increasing, though it appears that it is younger people migrating away, to be replaced by older, particularly retired, new entrants (DoW, 1992). More people want to move into rural areas too. Recent surveys found that 76 per cent of those who live in cities want to live in a village or country town and 37 per cent expect to move out during the next decade (Rose, 1993). The rural community, bonded in the past by a common understanding and economic interest in the land, currently appears unlikely to be brought together by close links with farming.

Various national enquiries have shown that the incidence of rural poverty is considerably greater than previously supposed (DoW, 1992; HL, 1990; ACORA, 1990). According to an unpublished government report, some 25 per cent of rural households are living on or below the official poverty line (in DoW, 1992). Farmers and farmworkers are about twice as likely to commit suicide than the rest of the population, and suicide is the second most common form of death for male farmers (in DoW, 1992). Farmers are increasingly recognized as suffering the stress and deteriorating confidence associated with lonely occupations (Martineau, 1993; Cornelius, 1993). The Duke of Westminster's report (1992) described these problems in this way: 'Hidden in the rural landscape which the British so much love, people are suffering poverty, housing problems, unemployment, deprivation of various kinds, and misery. Traditional patterns of rural life are changing fast, causing worry, shame and distress. Those most affected are often angry and bitter but feel they have little chance of being heard. The suicide rate is very high. Neither the public nor the private sector is showing any signs of caring very much about all this.'

Small family farms have been especially vulnerable (Lobley, 1993; Moss, 1993). They rely more on diverse sources of off-farm income and so are dependent upon the wider success of the rural economy. When small farms are given up, they tend to be amalgamated into ever larger holdings, with a resulting radical change in the landscape structure (Munton and Marsden, 1991). Many successions lead to intensified land use, and the removal of woods and hedges. Continuity of farms is a goal held by many farm families. Most wish to see their heirs as successors. Yet, the evidence suggests that few will do so. Since the late 1960s, the proportion of farmers planning to pass their businesses to their heirs has fallen from about 75 per cent to 48 per cent (Ward, 1993). Succession is also less likely for farmers in the less prosperous areas (Marsden et al, 1992). Farming's declining economic fortunes seems to have eroded the commitment to successors in family farming and the prospect of a farming career appears to have become less attractive to farm children.

Changes in Japan and the US

These changes are mirrored by social changes in other industrialized countries. In Japan, similar threats to rural culture are occurring. More than half of farmers are older than 60 years of age and 75 per cent are part-time, relying on jobs in manufacturing as their main income source. Only 16 per cent of all farms have a male under 60 years devoting more than 150 days each year to farming (Ohnox, 1988). Like many other parts of the world, the next generation shows little interest in the labour-intensive work of farming: 70 per cent of farms have no successor. The number of farm households has fallen from 5.82 million in 1960 to 4.2 million in 1991. In that time, the number of people living in a farming household has fallen from some 34 million (30 per cent of the population) to just under 17 million (14 per cent of population) (Iwamoto, 1994; MAFF, passim).

One woman farmer of a 0.2ha plot on the outskirts of Tokyo says her son, who works in an electronics factory, wants her and her 70-year-old husband to retire and sell the land to property developers: 'the young are not interested in the old ways and the old values. We have always owned land, it is the foundation and strength of our family. Our son says the land should be sold for building, or as a car park, but we believe everyone benefits from having farmers in the heart of the city' (in Davies, 1992). However, many say that looking down on their tiny plots of land from their tower blocks has helped them protect their sanity. Farmers fear that their rice culture is under terminal threat: 'people are lamenting the coming extinction of the two thousand year rice culture of Japan' (Furusawa, 1988). Nonetheless, it is also true that this culture has been heavily protected by national policies.

Just as in Britain and Japan, there have been huge changes in rural culture during this century in the US. Since 1900, the proportion of the national population who are farm residents has fallen from 40 per cent to just 1.9 per cent, or 4.6 million people (AAN, 1993). Family farms have been consolidated into larger farms; labour opportunities have fallen; and farm enterprises have been concentrated in fewer hands. This modernization has been most visible in the declining number of farms and the replacement of family farming by modern large-scale farming. But it has also had significant impacts on social systems.

A classic study conducted in 1946 by Walter Goldschmidt showed what happens when the social structure in the countryside changes during modernization (Goldschmidt, 1978). He studied the two rural Californian communities of Arvin and Dinuba in the San Joaquin Valley. These were matched for climate, value of agricultural sales, enterprises, reliance on irrigation and distance from urban areas. The differences were in farm scale: Dinuba was characterized by small family farms, and Arvin by large, commercialized farms. There were striking differences between the two communities. In Dinuba, there was a better quality of life, superior public services and facilities, more parks, more shops and retail trade, more diverse businesses, twice the number of organizations for civic improvement and social recreation, and better participation by the public. The small farm community was a better place to live 'perhaps because the small farm offered the opportunity for "attachment" to local culture and care for the surrounding land' (Perelman, 1976). A study of the same communities in the late 1970s reaffirmed these findings (Small Farm Viability Project, 1977).

Recent years have brought severe financial crises for family farmers. They were squeezed by debt and low product prices. Many thousands lost their businesses. Many others did not see this as a problem, but as desirable. It was widely perceived to be the way to agricultural prosperity. Michael Perelman (1976) quotes a Bank of America official who said in 1969 'what is needed is a program that will enable the small and uneconomic farmer – the one who is unwilling or unable to bring his farm to the commercial level by expansion or merger – to take his land out of production with dignity'.

Small farmers were widely taken to be economically inefficient. But their loss has been a severe loss to rural society. Linda Lobao's study (1990) of rural inequality shows the importance of the locality that Goldschmidt illustrated. The changing structure of farming has brought a decline in rural population, increased poverty and income inequality, lower numbers of community services, less democratic participation, decreased retail trade, environmental pollution and greater unemployment. The decline of family farming does not just harm farmers. It hurts the quality of life in the whole of society. Corporate farms are good for productivity, but not much else: 'this type of farming is very limited in what it can do for a community … we need farms that will be viable in the future, correspond to local needs and remain wedded to the community' (Lobao, 1990).

Wendell Berry, the influential poet and farmer, has long drawn attention to what happens during modernization. Agricultural crisis is a crisis of culture: 'A healthy farm culture can be based only upon familiarity and can grow only among people soundly established on the land; it nourishes and safeguards a human intelligence of the earth that no amount of technology can satisfactorily replace. The growth of such a culture was once a strong possibility in the farm communities of this country. We now have only the sad remnants of those communities. If we allow another generation to pass without doing what is necessary to enhance and embolden the possibility now perishing with them, we will lose it altogether.' (Berry, 1977)

One indicator of the crisis is the suicide rate among farmers. In the Midwest, suicide rates among male farmers were twice the national average during the 1980s (Gunderson, in FW, 1991). Some 913 took their own lives between 1980–1988, producing annual rates higher than for any other documented occupation.

Mexican Indians and modern agriculture

After centuries of avoiding incorporation into the wider culture of what is now Mexico, the Yaqui Indians of Sonora, situated in the north of Mexico and bordering the Gulf of California, have been entirely changed by rapid integration into the modern way of farming (Hewitt de Alcantara, 1976). They had been known for their tradition of strong social cohesion, cultivation of a great diversity of crops, and the use and management of wild foods, including wild fruits and oysters. They relied on small-scale water harvesting and irrigation structures to irrigate their crops from the seasonal rivers. But this has all changed.

In the 1940s, modern water control projects at Potam in the Yaqui Valley began to divert water to commercial farms. As more water was removed, the river ran low, making many families' plots unusable. Yaqui agriculture began to be undermined as they were coerced into joining the government scheme so as to have access to water. At the time, the state was trying to assure the permanent tranquillity of the tribe, and it was felt that commercializing Yaqui agriculture through water control and the formation of collective credit societies would help. During the 1950s, farmers were grouped into 40 credit societies, each containing some 30 members and their plots were joined to form the common land for each society. But external banks were given complete control of all farming decisions. Farmers had to grow wheat and cotton, and soon only 10 per cent of land was left under maize-beans-squash, with 90 per cent under wheat and cotton. The varied production of fruit and vegetables noted by visitors 20 years earlier had disappeared.

The local people had lost control over their own land, and the social and economic changes were significant. 'Instead of preparing and working their family plots by hand, using seeds from previous crops and silt from periodic river floodings, Yaqui cultivators found themselves observing the march of tractors and combines driven by bank employees across common land planted with high-yielding seeds and fertilized with chemical products. Most Yaqui indians intervened themselves only occasionally, when some menial task like cleaning irrigation canals or picking cotton demanded unskilled labour.' (Hewitt de Alcantara, 1976)

As a result of complete control by federal employees and no local participation or involvement, feeder canals soon became blocked, land badly levelled, fertilizer applied incorrectly and planting dates missed. Yields of wheat were too low to repay the loans which local credit societies had forced them to take on. All local households were heavily in debt in the early 1960s. Despite the Yaqui's fear of water, the government tried to set up a fishing cooperative. This failed. They tried a cattle cooperative, but this was run by a local bank and so lands were quickly overgrazed.

By the early 1970s, the whole process had thoroughly undermined traditional institutions, not least the family. It had ceased to be a productive unit, and its disintegration had led to clashes between the old and young, and a weakening of traditional religious and cultural components of life. Ceremonies previously good at maintaining a relatively equal distribution of wealth had broken down. A group of landless had appeared. Those made wealthy were mainly the shopkeepers, who were *mestizos* from outside the community. A few large farmers had appeared, utilizing hired labour only during peak seasons and occasionally renting additional land. About the only communal activity that remained was the cooperation for *fiesta* celebrations. As Cynthia Hewitt de Alcantara (1976) noted, such integration with the surrounding mestizo culture was no doubt inevitable, but 'the way in which it was enforced seriously damaged a tradition of economic and social democracy, local self-government, and community service which should have been valued at least as highly as material progress. More to the point, the modernization of Potam undermined these attributes without really bringing material prosperity at all – except to a very few.'

Social change in Indonesia

One of the earliest technological changes during rice modernization was the replacement of the traditional *ani-ani* knife with sickles and scythes for harvesting (Collier et al, 1973; KEPAS, 1984). By tradition, Javanese and Sundanese rice farmers did not restrict anyone wishing to participate in the rice harvest. The harvesters were mostly women from their own and neighbouring villages. They used the *ani-ani*, a small hand knife, to cut each stalk of rice separately. The rice sheaves were carried to the owner's house, where the harvester would receive a share of the harvest. In this *bawon* system, the owner kept seven, eight or nine shares to one for the harvester.

With the adoption of MVs with their short straw and simultaneity of maturation, rice could be harvested much more quickly by sickle or scythe. Owners increasingly adopted the new *tebasan* system of cash-and-carry for harvesting, in which the standing rice crop was sold to a trader, who then arranged for harvesting. With these changes, bands of men increasingly became itinerant harvesters and opportunities for income generation for women fell. Many were entirely excluded from the process of harvesting. In some parts of Java, there were 200 or more women harvesting each hectare of rice in 1970. By 1990, they had been replaced by 10–20 men (Salazar, 1992). At the Agro-Economic Survey at Bogor, Collier and his colleagues calculated that women's share of the harvest fell from 65 per cent in the 1920s to 37 per cent in the late 1970s (Collier et al, 1982).

But modern technologies have affected more than just women alone. The two-wheeled tractor is now used extensively in land preparation, and water pumps and tube wells have been introduced for irrigating rice. The potential impact of this mechanization can be gauged by the calculation that if all these modern mechanization techniques were introduced to Java, then over 3 billion person-hours of labour would be lost (Collier et al, 1982). This is equivalent to 2 million full-time employees or many more part-time workers.

In the early 1980s, Loekman Soetrisno and colleagues (1982) interviewed landless and nearly landless farmers in a well-irrigated and apparently prosperous village in Central Java. They were asked how agricultural development had affected their lives: 60 per cent answered that 'development has made us in a difficult position'. They said they were confused by the various government regulations, saying in particular that two were unfair. These were that all farmers in the village had to plant modern varieties on their rice paddies and that they had to follow a strict cropping schedule. Farmers appreciated the rationale, but could not abide by the regulations. They could not afford the modern inputs. They also 'did not have the courage not to abide by the regulations, as this would mean direct confrontation with the village bureaucracy'. They reported to Soetrisno that in 1978 one small farmer had to burn his rice when the local officials found out that he was planting a local variety.

The order to all farmers to plant rice in a fixed schedule had a major impact on social structure too. Unlike the richer farmers, the poorest did not have buffaloes or cows to help them plough the land. Neither could they hire extra labourers to work on their land. It was also the custom that before small farmers prepared their land, they would work first for richer farmers for the additional income. The new regulation prevented them from earning this income. As a result, they had to rent their land to richer farmers and become tenants on their own land, with the resulting loss of social status in the community. One January, this village was featured on national television news as 60 people had been found suffering from severe malnutrition. According to the village head, most of these were landless and small farmers (Soetrisno, 1982).

The decline of the traditional *sawah* system of rice production in Bali is an example of what can happen when a sustainable system is changed (Poffenberger and Zurbuchen, 1980). It was self-sufficient within the boundaries of a single watercourse. Complex social, ecological and economic linkages made the system sustainable and resilient for at least 1100 years. But, over just a few years, rice modernization broke apart these local relationships by substituting external processes. Pesticides replaced predators, and fertilizers replaced cattle and traditional land management. Government officials made decisions rather than local institutions, and local labour groups were replaced with specialist workers and tractors (Box 1.2).

Wheat and pastoralists in Tanzania

Another example of the social damage caused by modern farming comes from Tanzania, where millions of dollars of Canadian aid were spent between 1969 and 1993 in developing wheat farms on the dry Basotu Plains. Yields were comparable with those on the Canadian plains and the farms came to supply nearly half of the national wheat demand. But the plains are also the homeland of some 30–50,000 Barabaig pastoralists. The impact on their lives of these wheat farms has been recorded at first hand and documented in depth by Charles Lane (Lane, 1990, 1993, 1994).

The Barabaig economy is based on livestock production. Their herds of cattle, sheep and goats utilize the forage, water and salt licks found scattered throughout

Box 1.2 *The impact of modernization on the traditional wet rice cultivation system of Bali*

Wet rice has been cultivated in Bali since at least AD882. Irrigation cooperatives, the *subaks*, are responsible for the allocation of water and the maintenance of irrigation networks, as wet rice is too complex for one farmer to practise alone. Each *subak* member has one vote regardless of the size of landholding. Soil fertility is maintained by the use of ash, organic matter and manures. Rotations and staggered planting of dry and wet crops control pests and diseases. Bamboo poles, wind-driven noise-makers, flags and streamers scare off birds. And rice is harvested in groups, stored in barns and traded only as needs arise. Rice yields are typically 1–2t/ha, and sometimes as high as 3t/ha.

Modernization depends on the adoption of the whole new package. The major impacts have been as follows.

- Yields could be 50 per cent greater than under the traditional system, but only under optimum conditions, as the new rice was more susceptible to climatic and water variation.
- Pests and diseases increased as a result of the continuous cropping and the killing of predators and frogs by pesticides.
- Farmers sold cattle, as no they were longer needed for ploughing and manures.
- Mechanised rice mills displaced groups of women who used to thresh and mill the rice.
- Harvest teams replaced the communal *banjar* activities at harvest.
- As the new rice could not be stored for long periods (it had a thinner, looser husk and softer kernel), it had to be sold immediately after harvest when the prices were lowest. This meant men received large sums of cash, and the women could no longer plan for the year's food security by monitoring the rice barn. 'Wisdom lies in keeping the family's capital in the rice barn, where they can regulate and dispense it, rather than in the form of risky, hard-to-manage cash lump sums.'
- The *subak* organizations, once in complete control, lost many decisions to higher level institutions – now the government decides cropping patterns, planting dates and irrigation investments.
- The *subak* also organized redistribution through local religious and ritual culture, as the better off were expected to give more goods and services to community ceremonies.
- Reduced labour and employment in rice cultivation forced rural people to seek work elsewhere.

Source: Poffenberger and Zurbuchen, 1980

their territory. They have a complex grazing rotation system in which they move among eight different forage regimes. This can mean that some land is free of people and animals for long periods, which allows it to be preserved from overuse. All members of the community have access to communal land. But this access is not uncontrolled: certain areas and resources are protected by rights and obligations for individuals, clans and local groups. In the past, the customary rules and institutions had been effective in both maximizing production and conserving resources. The Barabaig, like many people who live in variable environments, have a tradition of respect for the land they rely on for their survival. Their elders recently said 'We value and respect the land. We want to preserve it for all time' (in Paavo, 1989).

But in order for wheat to be grown on the Basotu Plain, about 40,000ha of land was taken from the Barabaig. This was their most fertile prime grazing land. Some of them were forcibly removed and their homes burned. They were prevented from following traditional routes across the farms to reach pasture, water or salt resources. Many of their sacred graves were ploughed up and are no longer recognizable. There are also ecological problems, as the soil is left bare soon after the July harvest until the time of planting in February. This makes the soil susceptible to rain-induced erosion, and deep gullies have been created and the sacred Lake Basotu is being silted up.

Although the farms cover only 12 per cent of the total land area of the district, the loss of this area is crucial for pastoralist production (Lane and Pretty, 1990). By losing access to these fertile areas, the whole rotational grazing system has been disrupted, so reducing the pastoral productive capacity beyond the direct impact of the wheat farms. This loss has resulted in a drastic reduction of livestock numbers and a decline in production which the Barabaig say has caused them 'great suffering' (in Paavo, 1989).

Part of the problem is that outsiders misunderstand pastoralists and their production systems. Rangeland is common land to the Barabaig and individual herders move about in response to their assessments of range productivity or social needs. People who fail to understand this can be misled into thinking land is vacant or poorly managed by the pastoralists, so justifying their dispossession. One study of Canadian aid to Tanzania said: 'The project has many of the characteristics of a frontier development effort. Traditional pastoralists … are being displaced and absorbed into the project as labourers. Previously idle land is being brought under cultivation' (Young, 1983).

From the viewpoint of the farms, wheat production is financially profitable. A project evaluation conducted in 1980 arrived at a benefit/cost ratio of 1.59. The return to the capital of nearly 40 per cent also indicated that it was a 'very profitable investment for the Tanzanian economy' (Stone, 1982). But if the wider social and environmental impacts are accounted for, then the picture changes dramatically. The costs actually far exceed the benefits, and there would appear to be many better ways to use aid and scarce foreign exchange. As one economic assessment put it: 'The results of this study indicate that wheat production on the Hanang farms is profitable from the viewpoint of the farms… However, from the standpoint of contributions to, and resources used within, the Tanzanian economy the Project is shown to be uneconomic. In strict economic terms, the costs have exceeded the benefits' (Prairie Horizons Ltd, 1986). The financial resources spent developing a high input system in a remote and dryland region would have been more efficiently used for buying wheat on the world market.

Social change in India

Despite a wealth of studies on the impact of modern agricultural technology on the rural economy in India, there is no clear consensus as to whether labour opportunities for men and/or women have increased or decreased (Palmer, 1981; Agarwal, 1985; Chand et al, 1985; Whitehead, 1985; Sardamon, 1991; Chaudhri, 1992; Kaul Shah, 1993).

One recent study is now widely cited as evidence that the Green Revolution can lead to large, across-the-board gains in income, nutrition and standard of living for small- and large-scale farmers, and even for the landless poor (Hazell and Ramasamy, 1991). In North Arcot, Tamil Nadu, between 1974 and 1984, regional paddy output increased by 57 per cent, and this growth has had significant economic impact on the region's villages and towns. In addition to an increase in the wage rate, the distribution of income improved and absolute poverty declined. Small paddy farmers and landless labourers, who were initially among the poorest households, gained the largest proportional increases in family income, virtually doubling their real income during the decade. Non-paddy farmers and non-agricultural households increased their real family incomes by 20–50 per cent. As the authors put it: 'none of the predictions of the critics – that smaller farmers would be either unaffected or made worse off by the green revolution and that unnecessary mechanization would significantly reduce rural employment, thus worsening absolute poverty – came true'.

There is, however, considerable evidence that large-scale technological innovations tend to be followed by mechanization of some women's work (Whitehead, 1985; Palmer, 1981; Billings and Singh, 1970). This change displaces landless women workers and many of the tasks become 'male'. But there is also evidence to indicate that the demand for female agricultural labour can increase as a result of modernization (Agarwal, 1984, 1985; Chand et al, 1985).

One feature common to most studies on the impact of agricultural modernization is that they focus solely on employment, production and income distribution. Very few have considered the wider changes in livelihood strategies and the quality of life (Kaul Shah, 1993). But the introduction of technologies does not necessarily have to lead to social disruption. Where external institutions work closely with local people, then these new technologies can lead to improved welfare for men and women. A recent review of the activities of AKRSP in Gujarat has shown that since the introduction of modern varieties, fertilizers and plant protection measures, coupled with soil and water conservation measures organized on a watershed management basis, incomes of all households have increased since 1986 as a result of intensification (Kaul Shah, 1993). Rising agricultural productivity has increased the demand for local labour and so increased the opportunities for local work. This has made an enormous difference to the quality of people's lives. Both men and

Table 1.9 *Changes in livelihoods of men and women of Samarpasa village, Bharuch District, Gujarat, following the adoption of modern varieties, some fertilizers, and soil and water conservation measures as part of a participatory watershed management supported by the Aga Khan Rural Support Programme*

Criteria	*Before programme (1987)*	*After programme (1992)*
No. households migrating to Surat for 2–10 months of every year	42	6
No. women migrating without men	14	0
No. households not migrating	13	34
Agricultural wage labour (Rs/day)		
men	2	13–15
women	3	13–15
Number of village children in school	8	56
Regularity of full meals during summer	1 per 3 days	2 per day
Vegetable consumption	rainy season only	every day
No. bullock carts owned	0	19
Sources of livelihoods:		
agriculture	20%	60%
migrating labour	80%	20%
non-farm income/employment in village	0	20%
Women's involvement in decisions on purchase of vegetable seeds, milch animals tree saplings, clothing	none	regular
Ownership of clothing by women in landless and poorest group	1 set	3 sets

Source: Kaul Shah, 1993

women have experienced an increase in workload on their own farms, but it is the qualitative shifts in their livelihoods that people themselves say have been most significant (Table 1.9).

These qualitative changes were particularly important for women: their former work in labouring gangs in Surat was 'at the unbearable cost of insecurity, poor health, overwork, shame and loss of social respect' (Kaul Shah, 1993). The decrease in migration through substitution from local income-earning opportunities represents a significant improvement in welfare. Asked how they would describe being 'happy', women replied 'when we don't have to migrate to Surat and have enough to feed ourselves and our children'. This is despite the fact that wages are two to three times greater in Surat. Some of the most interesting changes recorded have been shifts in the work burden of men and women. Bullock carts are now used for gathering fuelwood and carting harvested rice from the fields, both formerly time consuming and heavy work for women. And where agricultural activities, such as weeding and paddy transplantation, were formerly segregated, they are now carried out by both women and men.

This is in fact a successful case of agricultural regeneration based on a judicial mix of local and external resources. Where it differs from the bulk of agricultural modernization efforts is in the formation of local institutions necessary for sustaining the changes. Once the migration cycle had been broken, people could stay in the village and were able to be fully involved in local decision making. These local institutions are a critical part of any effort for sustainable and self-reliant agriculture.

Summary

The pursuit of increased productivity and conserved natural resources in the course of rural modernization has produced benefits in the form of improved food production and some improvements in resource conservation. But these improvements look so good that it is easy to forget there have been losers as well as winners. All sectors of economies have been affected by modernization. The drive for agricultural efficiency has drastically cut the numbers of people engaged in agriculture in industrialized countries. External inputs of machines, fossil fuels, pesticides and fertilizers have displaced workers in Green Revolution lands. Rural cultures have been put under pressure, as more and more people have been forced to migrate in search of work. Local institutions, once strong, have become co-opted by the state or have simply withered away.

Many environmental and health impacts have increased in recent years; others have continued to persist despite all efforts to reduce them. These costs of environmental damage are growing, and are dispersed throughout many environments and sectors of national economies. A largely hidden cost of modern agriculture is the fossil fuel it must consume to keep outputs high. Modern agriculture has tended to substitute external energy sources for locally available ones. For each kilogramme of cereal from modernized high input conditions, 3–10MJ of energy are consumed in its production; but for each kilogramme of cereal from sustainable, low input farming, only 0.5–1MJ are consumed. A shift to low input systems could, therefore, have an impact on the process of global warming.

Pesticides have caused problems by inducing resistance in pests and damaging the health of farmers, farmworkers and consumers. The hazards are greater in developing countries and emerging evidence is producing a bleaker picture than appeared to be the case in the 1980s. According to the latest estimates from the WHO, a minimum of 3 million and perhaps as many as 25 million agricultural workers are poisoned each year, with perhaps 20,000 deaths. Studies in the Philippines, in particular, are showing how costly these problems are to national economies as well as to the affected individuals.

Despite the fact that indigenous systems of soil and water conservation are widespread, well adapted to local conditions, persist for long periods and are capable of supporting dense populations, soil erosion continues to be a problem throughout the world. To farmers, erosion reduces the biological productivity of soils and the capacity to sustain productivity into the future. Although soil erosion is clearly costly to economies as well as to farmers, it is difficult to calculate reliably the precise costs, though studies in Mali, Malawi and Java suggest that the costs to farmers are substantial, representing 3–14 per cent of gross agricultural product.

One surprising cause of soil erosion is bad soil conservation programmes. There are many examples throughout the world of impressive terracing and bunding disappearing when local people have not been involved in planning and implementation. Poor terracing results in worse erosion. The impact of these programmes has been to make many things worse. A failure to involve people in design and maintenance can create considerable long-term social impact, inducing widespread disenchantment among local people for all conservation projects that followed.

Biodiversity has fallen under modern agriculture. Farmers of traditional and low input agricultural systems have long favoured diversity on the farm, and it is only recently that fields monocropped to single species and varieties have become common. The introduction of modern varieties and breeds has almost always displaced traditional varieties and breeds. During the 20th century, some 75 per cent of the genetic diversity of agricultural crops has been lost. Only about 150 plant species are now cultivated, of which just three supply almost 60 per cent of calories derived from plants.

Agricultural modernization has helped to transform many rural communities in both industrialized and developing world countries. The loss of jobs, the further shift of economic opportunity away from women to men, the increasing specialization of livelihoods, the increasing concentration of land in the hands of wealthy villagers and urban investors, the growing gap between the well-off and the poor, and the co-option of village institutions for the purposes of the state, have all been features of this transformation. Cases are described of social change in Britain, Japan, the US, Mexico, Indonesia, Tanzania and India. In all of these the social costs have been substantial. Modern agriculture, though not the sole cause, has clearly been a contributor to these changes.

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2

The Performance of Low External Input Technology in Agricultural Development: A Summary of Three Case Studies

Robert Tripp

Introduction

There is widespread agreement that strategies for agricultural sustainability should help limit dependence on external inputs. There are many reasons to support low external input farming, including a concern for environmental sustainability, increased attention to the conditions of resource-poor farmers, and the conviction that a better use of local resources in small-scale agriculture can improve farm productivity and innovation. The pursuit of low external input strategies requires access to a wide range of alternative techniques for farm management. These may be elaborations of traditional practices, introductions from other farming systems, or innovations devised by farmers or researchers. These alternatives are referred to here as low external input technology (LEIT). This paper summarizes a study that assesses the performance of LEIT in three project settings and draws implications for the role of LEIT in pro-poor agricultural development.

LEIT is the subject of some controversy. On one side, some dismiss it as a collection of hopelessly labour- and knowledge-intensive practices that have little relevance to agricultural development. On the other side, LEIT may be promoted as the key to small farm survival and the development of human and social capital in farming communities. This study tries to chart a course through such arguments by examining the utilization of LEIT in three important examples, attempting to draw conclusions that have wider relevance. The next section of the paper introduces the three projects on which the study is based. This is followed by an examination of the labour requirements of LEIT. The next section reviews concerns about knowledge-intensity, followed by a section examining the incentives for utilizing LEIT. The degree to which LEIT, once adopted by some farmers in a community,

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can diffuse to others is the subject of the next section. This is followed by an examination of the hypothesis that local-level development of LEIT can make significant contributions to strengthening human and social capital. The paper concludes with some considerations regarding the effective promotion of LEIT.

The Study

The research reported here is based on three case studies (in Honduras, Kenya and Sri Lanka); a more complete description is available in Tripp (2005). The study sites were chosen following several criteria. The cases all examine relatively large projects that introduced examples of LEIT to many farming communities; this avoids possible biases related to the analysis of pilot project experiences. The cases were chosen from among well-managed LEIT projects to avoid confounding technology performance with problems in project management. In addition, the cases were chosen on the basis of evidence that some of the examples of LEIT had been taken up by a significant number of farmers. Finally, the research was organized to examine the experience of participating farmers (and their neighbours) at least five years after the termination of project activity. Assessment of technology adoption is often difficult in the immediate aftermath of a project, and the research was particularly interested in understanding further technology adaptation, diffusion, or abandonment, as well as seeking opportunities to examine the evolution of any project-related human and social capital. Table 2.1 presents a summary of the three cases.

The field research followed a similar pattern in the three sites, although differences in project organization were responsible for some variation in research protocols. Once the focus projects had been chosen, initial field visits were devoted to selecting appropriate sites, identifying participant communities whose experience seemed typical of the project, and finding comparable non-project communities to serve as controls. Researchers held informal discussions with farmers in the area and conducted small focus group exercises to gain a better appreciation of the important issues. Discussions were also held with local officials and others, and all relevant secondary data were examined. Researchers then selected random samples for a formal survey. In each case the samples included: (i) project participants, (ii) non-participants from the same community, (iii) farmers from nearby 'control' communities. The total sample sizes were 178 (Honduras), 128 (Kenya), and 210 (Sri Lanka). The researchers were present for all the interviews, although trained enumerators were used in Honduras and Sri Lanka. The interviews focused on general farming practices and conditions, not on the project per se. The interviews included details of current farming practices, those of the recent past and sources of information. The survey data were analysed and appropriate statistical tests were utilized. Lack of space in this paper precludes discussing detailed examples, but the reader should assume that any relationship described below (e.g. the correlation of a particular practice with a particular farmer characteristic) exhibits statistical significance (unless otherwise stated).

Table 2.1 *Summary of case studies*

Case	*Honduras*	*Kenya*	*Sri Lanka*
Project	NGO projects in central Honduras, beginning in late 1980s, for soil restoration on hillside farms. Each project included 30–35 villages.	National Soil and Water Conservation Programme, 1988–1998, worked in catchments of 2–300 contiguous households. Study done in Nyanza Province.	Sri Lanka Department of Agriculture and FAO supported 610 farmer field schools for IPM nationwide, 1995–2000. Study done in Southern Province.
Technology	In-row tillage, cover crops, physical barriers.	Small terraces, vegetative strips, unploughed strips, retention ditches.	Reduction of insecticide use; straw incorporation, single-nutrient fertilizers.
Participants	Open to all members of village; various levels of participation, from development of farmer leaders to occasional attendance at activities.	Majority of farmers in project villages signed up to participate, had farms surveyed by committee and discussed options.	Participation in farmer field school limited to about 20 farmers per village.
Labour input	Majority of in-row tillage and cover crop adopters say these save labour. Few who abandon technology cite labour input as a reason.	Strips more popular than physical structures, partly because of lower labour requirement. Adoption related to household labour availability.	Reducing insecticide lowers labour and cash investment, with no yield penalty. Straw incorporation requires labour but increases yields.
Technology utilization	Majority of participants continue using some LEIT. Utilization related to access to irrigation, area under cash crops; not related to farm size or slope of field.	Majority of participants establish some structures, but at low density. Greater use in high potential areas and on farms dependent on crop sale.	Those who work as farm labour less likely to participate and rely more heavily on insecticide. Rice is important income source.
Diffusion of technology	Most adopters share information with others. Little spread of technology in project villages; some (largely temporary) uptake in neighbouring villages.	Modest evidence of subsequent diffusion to neighbouring villages, but other projects promoting similar technology.	Little evidence of spread of IPM message to other farmers, despite enthusiasm of participants.
Further group activities	Participants and adopters belong to more groups, but no permanent organizations emerged from project.	Most catchment committees ceased activities after project completion. Various other projects draw on former participants.	Few groups survive after project; continued activity depends on extension or other project support.

The Honduras case examines the experience of several related NGO projects that promoted sustainable hillside farming, with particular attention to methods for soil fertility enhancement and soil and water conservation. The projects followed earlier successful experience elsewhere in Central America (Bunch, 2002) where participating farmers were motivated to experiment with new techniques and to build on recognizable success rather than rely on subsidies. The study revisits two of the areas in central Honduras where the projects took place. These are areas where previous slash-and-burn agriculture has evolved to permanent cropping on increasingly eroded hillside plots; farmers plant twice a year, with maize as the principle first season crop, followed by beans in the second season. Vegetables are the most important cash crop. The study examines experiences with techniques such as in-row tillage and the use of cover crops.

The Kenya case focuses on the National Soil and Water Conservation Programme, which featured a catchment approach where communities were encouraged to learn about and establish soil and water conservation techniques (Pretty et al, 1995). Elected local catchment committees served as major actors in the project. The programme was active from 1988 to 1998 and was national in scope. The study examines the aftermath in a set of communities in high- and low-potential areas of Nyanza Province, western Kenya. The principal subsistence crop is maize, but beans, banana, groundnut, sweet potato and sorghum are also grown. Maize and groundnuts are the principal cash crops. Farmers in the high-potential area are able to plant in both the long and short rains, but those in the low-potential area rely only on the long rains.

The Sri Lanka case examines an example of farmer field schools (FFS) for introducing Integrated Pest Management (IPM) and other crop management techniques in rice (Pontius et al, 2002). The Sri Lanka programme was managed by the Department of Agriculture, with assistance from the Food and Agriculture Organization (FAO). The study was conducted in communities in Southern Province, among farmers with access to irrigated paddy land. These farmers are generally able to plant two rice crops a year and this is a major source of income, as well as contributing to household subsistence. Most farmers also have at least a few tree crops and a minority have access to an upland field. The FFS concentrated on helping farmers lower the use of pesticides, particularly early in the season. It also supported the incorporation (rather than burning) of rice straw and promoted more rational fertilizer management through single nutrient fertilizers, rather than blends that had previously been promoted.

In each of the three cases there was clear evidence of the utility and continued relevance of various examples of LEIT introduced in the original projects. In Honduras, more than half of the participating farmers continued to use in-row tillage on part of their fields. (The technique involves planting on the contour and hoeing only within the row, in order to promote the formation of mini-terraces.) About one-fifth of the participants were using a green manure crop with their maize and about one-third had established some kind of live barrier for soil conservation. In Kenya, more than half of the project participants surveyed implemented at least one soil and water conservation structure during, or shortly after, the catchment project; the most common technologies were grass strips or unploughed strips. In Sri Lanka, the FFS participants made only one-third as many insecticide applications on their rice compared to other farmers, and there was also evidence that they tended to be further ahead in several aspects of soil fertility management such as the adoption of straw incorporation and the rational management of purchased fertilizers.

Given that the three case studies were focused on projects specifically chosen because of initial evidence of wide coverage, good management and relevant technology, it is not too surprising to find that there is still widespread utilization of LEIT five or more years after project activities were completed. However, the reason for selecting such cases was not merely to document continued technology use but rather to examine differences in utilization among farmers, the extent to which the technologies were subject to autonomous adaptation and diffusion, and their possible contributions to strengthening human and social capital.

Labour

Perhaps the most frequent criticism of LEIT is that it is labour intensive. Labour is a major constraint in smallholder farming and there are many instances where farmers show little interest in a technology because of its excessive demands on labour. The rejection of some types of LEIT because of high labour requirements is well known; the very limited success of alley cropping in Africa is but one example (Carter, 1995). Such cases are sometimes used to characterize LEIT more broadly, but we need to look more carefully at how labour requirements determine the acceptability of a technology. There are many examples where farmers are willing to invest additional labour if the payoffs are adequate. In addition, there is good evidence that the timing of labour demands may be as important as the absolute amount. There are also important questions, particularly relevant to LEIT, regarding whether the major labour investment is for learning and establishing the technique, or is required for its repeated performance. Pretty (1995) sees the initial investments as part of the 'transition costs' required to shift from conventional to more sustainable agriculture. Finally, once farmers gain experience with a new technique they are often able to manage it more efficiently than when they were first introduced to it.

Thus the implications of additional labour demands for the acceptability of a new technology are related to the flexibility available in the farming system, farmers' incentives to adopt new techniques, and opportunities to learn and adjust. The experience of the case studies demonstrates that simply characterizing LEIT as labour intensive overlooks these determinants. For example, the time that FFS farmers in Sri Lanka spent in learning about pest management in irrigated rice enabled them to permanently reduce their time and cash investments in insecticide application. This involved no additional control practices and no loss of yield, a win–win result. A more complex case involves in-row tillage in Honduras; it requires some extra initial labour investment but most farmers say that once established it makes weed control easier. A number of farmers tried the system and then abandoned it, but few of these mentioned labour requirements as a problem. Nevertheless, labour remains a factor in the diffusion of many types of LEIT. More Kenyan farmers established soil conservation measures with lower labour requirements (such as unploughed strips) rather than labour-demanding techniques such as terracing, and attempts to introduce FFS participants in Sri Lanka to green manures were unsuccessful, partly because of the labour implications.

A factor that further complicates the analysis of so-called labour-intensive technology is the fact that a considerable proportion of the labour used in even very small farms is hired. Where labour is a purchased input, the definition of low external input technologies becomes problematic. In Honduras, a sub-sample of farmers estimated the labour implications of establishing in-row tillage, revealing that half of the labour for this task was hired. In Sri Lanka, 70 per cent of the farmers hired labour for spraying insecticide and 64 per cent hired labour for planting, even though the average farm size is barely 1ha. Similarly, more than 60 per cent of the farmers in the Kenya study hired labour for weeding. A common defence of LEIT is that conventional technologies relying on purchased inputs favour those with cash resources, but as small farms come to depend increasingly on hired labour this distinction becomes less relevant. The notion that LEIT necessarily favours family labour on small, self-sufficient farms needs to be re-examined.

Labour-generating LEIT can reduce seasonal or permanent migration by offering local employment, but we need to understand whether people are working on their own, or others', farms. In Niger, for instance, the introduction of planting pits (a labour-intensive technique for building soil fertility and moisture conservation) has helped rehabilitate degraded land and improve yields (Hassane et al, 2000). The success has contributed to an emerging land market, but the purchasers are concentrated among a rural elite who are able to hire labour to establish the planting pits.

Thus various types of LEIT (like conventional technology) exhibit a wide range of labour profiles and a simple characterization of labour intensity masks more important considerations of flexibility, adaptation and incentives. Although LEIT may substitute labour for purchased chemicals or fertilizers, the labour may itself be an external input; differences in the ability to purchase that input may have implications for rural equity that are as important as differential access to other farm inputs.

Information

Technologies have different information characteristics (and hence make different demands on farmers to acquire that information and take control of it as knowledge). LEIT is often characterized as being information- or knowledge intensive, but this generalization needs to be disaggregated. In a review of low external input strategies, Lockeretz (1991) points out that we need to know: if such technologies are information intensive solely to develop or also to adopt; if the latter, whether the additional information needs to be acquired at only one time or whether it needs to be continually sought and updated; and whether the acquisition of the additional information requires only an investment of time or also implies new skills. It is difficult to argue that LEIT can be distinguished from conventional technology with respect to information intensity, especially with the demise of subsidized input packages. Byerlee (1998) believes that farming in industrialized countries and in Green Revolution areas in the South will have to pass from the stage where knowledge is 'embedded' in the inputs provided to farmers to a stage where information itself becomes a more important element. The provision of information will have to shift from general area-based recommendations (e.g. for fertilizer use) towards qualitative season- and site-specific advice, as exemplified by the rise of precision farming.

The case study examples of LEIT offer a range of examples of information requirements. Lowering insecticide use in Sri Lanka is a straightforward action, but it appears to require a fairly significant investment in learning about pest ecology and gaining confidence in the efficacy of natural pest control processes. The logic and implementation of grass strips in Kenya seems fairly straightforward, and farmers are able to make adaptations once the strips are established. In-row tillage in Honduras involves a process of gradual establishment and adaptation over several seasons.

Who Utilizes LEIT?

Both the information and labour requirements of alternative technologies must be considered in light of the incentives for investment. Farmers will make an effort to acquire new information (or invest in additional labour) when it yields a reasonable return. This helps explain why the general pattern of utilization of LEIT in the case studies is surprisingly similar to that of conventional technology. LEIT tends to be taken up by farmers who have greater commercial farming opportunities.

In the Kenyan case, uptake of conservation practices was much greater in the high potential area, where agriculture made a more important contribution to livelihoods. Users of the conservation practices have both larger farms and more cattle, although the relation is not statistically significant. In the higher rainfall zone in the Kenya study, those who established conservation structures on their farms earned a higher proportion of their incomes from crop sales. Those Honduran farmers with greater areas of cash crops and access to irrigation were significantly more likely to utilize LEIT, and the majority of instances of in-row tillage were for vegetables rather than basic grain crops. In Sri Lanka, on the other hand, the range in farm size is quite narrow and there is no correlation between rice area (or commercial rice sale) and insect control practices. On the other hand, it may be argued that the FFS addressed a rural elite (those with irrigated land), and rice sales contributed an average of 43 per cent of cash income for farmers in the sample.

There is also some evidence that LEIT allowed participants to expand their commercial farming. This is particularly true in Honduras, where it appears that specific practices such as in-row tillage (as well as the experience of participating in local technology testing and generation) were a stimulus for some farmers to begin commercial vegetable cultivation. In the high potential zone in Kenya, the option of growing grass strips for erosion control was made more attractive because of a concomitant promotion of zero grazing; farmers could harvest the Napier grass for their own cattle or sell it to neighbours.

The limited literature on the adoption of LEIT tends to reach similar conclusions. The use of a cover crop in northern Honduras was associated with farmers who grow larger amounts of maize and are more commercially oriented (Neill and Lee, 2001). A study of farming practices in an area of western Kenya showed that wealthier households are more likely to use low-input soil management techniques (fallows, compost, terraces) as well as external inputs (hybrid maize, inorganic fertilizer) (Crowley and Carter, 2000). The initial experience with the System of Rice Intensification (SRI) in Madagascar indicates that adopters are more likely to be surplus rather than deficit rice producers, with more land and often with better off-farm sources of income (Moser and Barrett, 2003).

The issue of off-farm income is important. Off-farm opportunities can provide extra cash to invest in agriculture or may offer alternatives to a moribund agricultural economy. In the high potential zone in Kenya, there was a negative correlation between income from business or petty trade and the uptake of conservation technologies. In Sri Lanka, in contrast, farmers who earned a higher proportion of their incomes from salaries or trade were as likely to be interested in IPM as those whose income was predominantly from agriculture. Possible explanations for the difference between the cases include the feasibility of balancing the various income-generating activities (e.g. petty trade in the Kenya case may keep the farmer away from the field) and perceptions of the profitability of investing in agriculture.

However, when a household's off-farm income opportunities are confined to casual labour there is less room for manoeuvre. In Honduras, most farmers were engaged in some off-farm labour, but those farmers in the lowest resource wealth category had the highest dependence on off-farm income and the lowest use of LEIT (or mineral fertilizer). In Sri Lanka, although there was fairly broad interest in the FFS, those farmers who also worked as casual labour were significantly less likely to participate (and used more insecticide than anyone else). Crowley and Carter (2000) describe the downward spiral of unskilled rural migrants from western Kenya who have too little time or cash to invest in the improvement of their own farms and end up working for others or migrating in search of employment.

Such households are unlikely to be able to take full advantage of LEIT programmes.

Diffusion of LEIT

There are hopes that LEIT may diffuse fairly rapidly to other farmers. If a technology is a product of local innovation or adaptation, it may find an understanding audience among neighbouring farmers, and if it relies on local resources it may be more straightforward to adopt. However, the case studies do not support these hopes for spontaneous diffusion. Although most of the participants in the case study projects were enthusiastic about their experiences and reported describing ideas and concepts they had learned to other farmers, there was only modest evidence that non-participants learned about particular techniques from project farmers. In Honduras, there was little adoption of in-row tillage and cover crops by non-participants, although about one-quarter tried out the technologies. The majority who tried the techniques learned about them from other projects, although some also reported learning from other farmers. In Kenya, farmers in some neighbouring communities established soil conservation techniques a few years after the project; the proximity of the project community certainly was important, although there are various other projects promoting these techniques in Kenya. In Sri Lanka, there was no evidence that FFS farmers played any significant role in convincing their neighbours to reduce insecticide use. It was more common that neighbour farmers had remembered (and acted upon) information from the project participants about soil fertility management than about pest management.

The lack of diffusion of LEIT technologies and principles from these well-managed and relatively successful projects must be taken into account when considering future strategies for the promotion of LEIT. Farmers require a certain amount of hands-on experience before they are motivated to utilize many of these techniques, although there is considerable variation. In some cases (e.g. grass strips or straw incorporation) the techniques are quite visible to neighbouring farmers, who are capable of copying the ideas with a minimum of experience. In other cases (e.g. in-row tillage) farmers need a period to learn and experiment with the technique and the experience is more difficult to communicate. And in cases where complex principles are the basis for a change in practice (e.g. agroecological analysis and the rationale for IPM) farmers may find it particularly challenging to articulate what they have learned to their neighbours. The lack of diffusion of the IPM message for irrigated rice, despite the success of FFS in Asia, is a particular concern (Tripp et al, forthcoming).

LEIT is often seen as an important shift in attitude towards farming rather than merely a set of innovations. If the uptake of LEIT involves a change in the perception of farm management, we would expect that those farmers who utilized one type of LEIT would be more likely to lower their use of external inputs in general. This does not seem to be the case, however. Honduran farmers who use in-row tillage and Kenyan farmers who establish conservation structures are both more likely to use fertilizer on their food crops. In these cases, the LEIT provides an environment in which a profitable fertilizer response is more assured. These examples illustrate that there is no necessary connection between the use of one type of LEIT and a general reduction in external inputs. In most cases, farmers make decisions about various crop management technologies independently and pragmatically, without reference to any overarching philosophy regarding external inputs. In addition, farming systems evolve and require the consideration of new management practices. The success of the LEIT project in Honduras is one of the factors that motivated some farmers to begin commercial vegetable production and this has led to a considerable increase in the use of pesticides (and there is no indication that vegetable growers employing in-row tillage use less pesticide than their neighbours who use conventional tillage).

This is not to say that farmers are unaware of environmental concerns or that the LEIT projects were not successful in helping encourage farmers to consider the importance of resource conservation. Rice farmers in Sri Lanka were anxious to extend what they had learned about IPM to vegetables, but had not been able to do so. In some cases those farmers credited environmental concerns for their interest in IPM, and FFS participants were much more likely than the non-participants to cite environmental rather than economic reasons for their choice of practices, but there was no evidence that such rationale took precedence over economic factors in decisions about technology use.

Human and Social Capital

Because LEIT utilizes local resources, is often developed through adaptive experimentation, and may be introduced through processes of social learning, it is reasonable to expect that it can make a greater contribution to the development of individual farmers' skills and broader community capacities than the introduction of conventional technology. LEIT projects often make a conscientious effort to promote these goals of developing human and social capital. The project in Honduras put particular emphasis on farmer experimentation and support to farmer-extensionists, following a model developed earlier (Bunch, 1982). Organization of conservation work in the Kenya case was guided by an elected committee, and the FFS approach used in Sri Lanka is well known as an effective application of social learning techniques.

In many instances, the technology introduced by the projects led to subsequent adaptation. In Honduras, about one-fifth of the participants who established in-row tillage made some type of modification subsequent to the initial adoption. Similarly, about one-third of the Kenyan farmers who established a conservation structure made further adjustments, such as combining structures or altering the width or management of vegetative strips.

It is more difficult to assess changes in farmers capacities for experimentation (Sumberg and Okali, 1997). The strongest evidence is from Honduras, where the project put particular emphasis on developing experimental skills. About one-fifth of the participants reported at least one experiment carried out subsequent to the project. In addition, a higher proportion of farmers who utilized LEIT reported trying alternative pest control techniques in maize (although they used no less chemical pesticides than other farmers). In the other two cases there was much less evidence of farmer experimentation. Projects that emphasize simple field experimentation can stimulate farmers to continue with their own investigations, but the case study examples do not support the view that LEIT projects, on their own, can set off a burst of local innovation. The comparison between FFS and local agricultural research committees presented by Braun et al (2000) emphasizes that the development of experimental capacities often requires a more long-term approach.

Because many LEIT projects feature group methods there is an expectation that successful experiences will lead to further organizational growth and innovation (e.g. Pretty and Ward, 2001). However, there was very little evidence that participation in an LEIT project was sufficient to maintain the original groups formed for the projects or to lead to further organizational development. In Honduras, farmers who participated in the project belonged to more organizations, but the project did not lead to any further group initiatives. On the other hand, the satisfaction some project participants experienced in acquiring useful technology may have encouraged their subsequent participation in other organizations. The density of rural organization in Kenya is the highest of the three cases, and although some of the catchment project participants went on to participate in other activities it is difficult to attribute this to the project itself. In only one site did part of a catchment committee remain together for further activities. In Sri Lanka, the FFS functioned for a season and then disbanded; the only exception was one case in which another extension activity (in seed production) drew on the members of a previous FFS.

LEIT projects are established in communities where social networks are already in place. If the projects are competently managed, they may contribute to further group-led initiatives. But the idea that a technology generation project has a high probability of leading to further, spontaneous group action is erroneous. Community organizations develop for various reasons, but permanent, autonomous capacity requires particular incentives. The high density of donor projects in certain areas can contribute to an image of organizational growth, as a group from one project is inherited by a successor project. But significant organizational development requires adequate incentives and local commitment, and often depends crucially on outside resources as well. A community in Honduras that served as an interesting contrast to the two principal project areas of the study provides a good example. The community demonstrated a very high uptake of LEIT and exhibited excellent local organization. But pre-project activity (including interventions from several external individuals and agencies) had already led to the development of a producers' cooperative. The community's location close to markets, its strong leaders, and opportunities for producing organic coffee all contributed to further success and particular interest in LEIT. The project played an important role in supporting this activity, but we can expect such a confluence of favourable circumstances in only a minority of cases.

The conclusion that the projects did not make the contributions to human and social capital that some LEIT advocates envision should not, of course, be taken as the final word on the subject. Identifying changes in individual or organizational capacity is not straightforward, and more innovative research methods may be developed to investigate this issue. But at this point we should be sceptical of any claims made on the basis of anecdotal evidence, and descriptions of project merry-go-rounds should not be taken as demonstrations of sustainable local capacity. In addition, just as the distributive implications of the technology require investigation, biases inherent in project strategies must be addressed. For instance, Gugerty and Kremer (2002) argue that some bottom-up rural development projects organized through groups may offer more opportunities for resource capture by an elite than do traditional top-down activities.

Effective promotion of LEIT

These results have implications for the way that LEIT is promoted. First, it is necessary to address the fact that LEIT does not necessarily reach the poorest farming households. A cogent criticism of some of the early support for the Green Revolution focused on the unreasonable expectation that technology could effectively redress inequalities in access to resources. The seed-fertilizer technology did not do this, and neither does LEIT. Place et al (2002, p281) conclude that natural resource management technologies, 'like agricultural technologies more generally, fail to be adopted by women farmers and poor farmers at the same rate as male farmers who enjoy greater wealth, education and socio-economic power'. Careful targeting and extra resources to include the poor in project activities may help redress these imbalances, but such strategies do not obviate the need for a much more realistic assessment of rural livelihoods. There are many so-called farming households that depend only marginally on agricultural activities. Their plight deserves particular attention, and solutions may include political reform that provides more equitable resource distribution, development of rural infrastructure and services, identification of alternative opportunities for rural labour and enterprise, and effective safety-net strategies for the vulnerable. Agricultural technology is only one part of the solution to persistent rural poverty, and technology projects must be linked with broader rural development strategies.

LEIT (or any other technology) has a much better chance of making an impact in situations where there is a dynamic agricultural economy. The case studies clearly showed that farmers engaged in commercial agriculture were more likely to take advantage of LEIT, and that those with fewer agricultural opportunities were in danger of neglecting farm stewardship, in some cases actually depending more heavily on external inputs such as pesticides. There are many instances where the use of LEIT is preferable to dependence on purchased inputs, and LEIT can make an indispensable contribution to farm management. The environmental motivations behind the promotion of LEIT remain valid, but these are rarely the principal factors in farmers' decision making. An approach that provides farmers with a wide range of opinion, information and options would seem, in the long run, a more productive strategy than one that insists on a fairly narrow ideological stance. It is possible to dismiss the notion that LEIT represents some kind of separate technological realm that automatically brings with it altered incentives and attitudes for farming but at the same time acknowledge the importance of developing a more thoughtful and varied use of local resources and knowledge. To insist that LEIT stands apart (as a minority of its practitioners do) is inefficient and unrealistic.

How can the lessons, techniques and motivations that characterize the best work in LEIT be promoted? The problem is often discussed in the context of the high per-participant costs of successful projects, and the usual policy prescription is scaling up. But given that any intensive local-level endeavour involves considerable start-up costs, and taking into account the fact that many LEIT projects are limited in breadth and focus, the search should be for economies of *scope* rather than *scale*. That is, the emphasis should be on establishing modalities through which farmers have access to a sustainable source of information and support for broad agricultural innovation rather than being subject to a series of projects, each one concentrating on a few specific technologies and often covering a relatively limited number of communities. Each project may have a separate focus and unique methodological preferences that militate against wider application. It should not be surprising that this strategy rarely results in the development of human and social capital.

Although it is fashionable to talk about offering farmers 'a basket of choices', the baskets developed by many LEIT projects are unacceptably limited. Attention to agricultural sustainability has highlighted the dangers of conventional agricultural technology simplifying farming systems and relying on a narrow range of options, lowering diversity and resilience. But efforts in LEIT are also subject to faddism and uniformity. Methodological uniformity is also a problem, as in the rush to organize farmer field schools for almost every subject imaginable. There is also a need to build further technical competence. NGOs can offer support for farmer organization, advocacy and local technology testing and adaptation, but something as complex as LEIT is not effectively promoted by well-meaning but inexperienced generalists.

The project approach to LEIT involves unrealistic assumptions about the possibilities of engineering local innovations and too little attention to building underlying capacity. There are very strong justifications for encouraging the emergence of viable groups, but these need to be based on interests that are broader than those of the usual LEIT project. Groups offer efficiencies in information transmission, form a basis for social learning and can help foster environmental consciousness. Much agricultural technology requires hands-on learning, and groups can facilitate access to these opportunities. In addition, group action is usually the most effective way for farmers to draw on external resources. Rather than serving as gatekeepers for access to agricultural research stations, projects should strive to make farmers understand that public research belongs to them and that a visit to an experiment station to seek attention to pressing problems is a right rather than a brokered privilege. Similarly, developing strong, broad-based farmer organizations that can exert pressure for more effective public extension may have higher payoffs than small-group activity in response to a brief donor project.

Current project-driven group formation related to LEIT is based on much too narrow a base, sometimes the development of a single technology. Project activity is an inefficient way of making up for deficiencies in basic education, information and markets. Farmer organizations will only be sustainable if they address major issues of concern to their members. Access to technology may be one of these, but it is unlikely that technology generation, on its own, will be the basis of a significant growth in viable organizations; it is less likely that specific technological issues (IPM, soil erosion control) would provide such a basis. Organizations need to offer as many advantages to farmers as possible in order to elicit commitment and offer opportunities for varying levels of participation. The transaction costs of group formation are considerable, and there is no sense in repeatedly making such investments for a series of short-term, isolated interests. The various initiatives with resources and rationales for group activities related to LEIT need to join forces in order to make a contribution to building sustainable local institutions.

Summary

LEIT includes an exceptionally wide array of technologies that challenge any attempt at generalization. Nevertheless, this study of three large and well-managed projects, combined with an extensive review of the literature, provides a basis from which to offer some fairly broad, but hopefully robust, conclusions. There are many instances where farmers are able to take advantage of LEIT. The technologies help farmers become more productive and conserve resources, and these techniques deserve further investment in research, development and promotion. However, the use of LEIT is much less widespread than some observers would hope. In addition, LEIT does not necessarily behave the way that either its supporters or sceptics maintain. On the one hand, LEIT is certainly not the rudimentary, hopelessly labour-demanding technology that some critics assume. On the other hand, despite its focus on self-sufficiency and its concern for marginal farming conditions, most LEIT is not particularly targeted to the poorer members of farming communities; its adoption exhibits patterns similar to those of conventional agricultural technology. In addition, the diffusion of the technology from farmer to farmer is often slow. Finally, despite the fact that LEIT is promoted as an approach to farming rather than as a particular technology, there are very few examples where LEIT efforts have served as a spark to ignite further individual innovation or group action.

These conclusions provide further evidence that there are no easy answers for improving the welfare of poor rural households. Although certain technologies are more appropriate than others for resource-poor farmers, time and resource constraints – as well as the demands and opportunities of off-farm income – limit the degree to which low-input farming can make important contributions to the poorest households. This implies a more realistic approach to policies for rural poverty reduction and full consideration of the role of non-agricultural opportunities. Where agriculture is important for household livelihoods, technology-specific, project-based strategies are inadequate. Much more attention is required for information provision and the development of broad-based organizations that allow farming households to gain access to the widest possible range of innovations.

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3

The Politics of Food: An Introduction

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In recent years, food has emerged as a political topic par excellence. Capable of connecting individual bodies to abstract communities and techno-scientific innovations to moral concerns, food has become a highly charged and contested field. Recent food scandals, such as the outbreak of BSE (bovine spongiform encephalopathy) and the public debates over GMOs (genetically modified organisms) have shattered the idea that 'food is food' as we always knew it, and have exposed fundamental dilemmas of modern food production related to risk and control. At the same time, food is increasingly involved in controversies at a transnational level, in relation to issues of access, dominance, trade and control in what is seen as a shared global environment. Such controversies have placed food at the forefront of political debates both within and between nationstates.

Not long ago, the term 'Politics of Food' would have drawn notice to a fairly specific set of problems within a particular set of arenas. The politics of food would have taken place within the domain of state bureaucracy. The term would have denoted a range of issues such as food security, social inequality, nutrition policy and agricultural policies. Focusing on the micro level, the politics of food could also involve the gendered and unequal distribution of food and labour within the household (Murcott, 1982; Charles and Kerr, 1988; Counihan, 1999). Going beyond the level of the state, the term might have applied to the study of unfair trade, the dominance of multinational corporations and food as a human right (Eide et al, 1984). Most importantly, the term 'politics of food' would have focused attention on the access to food at different levels of scale and the problems of matching access to needs. In other words, seeing food as a source of nutrients, and politics essentially as what political institutions did (or ought to have done), the *politics of food* would have been located where the two came together.

Since then, the field has been extended in novel directions. In light of current controversies, a purely institutional approach to food politics is, in itself, no longer capable of capturing the vast array of connections that relate to food production,

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distribution and consumption. We do not argue here that institutional approaches to the politics of food are irrelevant, nor that the issues of need, access, nutrition policies and global inequalities are less important today than they were a generation ago (see Pottier, 1999; Hart, 2001). Rather, we argue that contemporary issues require that our notion of the politics of food is expanded to fields and arenas not traditionally thought of as 'political'. Accordingly, our aim is to draw attention to some of the less obvious ways in which food is politicized. Most contributions to this book are inspired by anthropological perspectives on food and eating, and many apply an ethnographic approach. Yet, this book is not strictly anthropological, as it draws on insights and methods that are central also to other disciplines in the humanities and social sciences, most notably linguistics, political science, history and sociology.

To indicate that the politics of food takes place both inside and outside the arenas normally designated as political is to draw attention to controversy, hegemony, resistance and conflicts of interest that underlie both the structuring of food choice and the structuring of public and media agendas. But it also implies drawing attention to how food itself has become a political object. These issues are elaborated in the introduction. But first, let us briefly recapitulate some events that have changed the way we think about the food we eat.

What Happened? Transformations of Substance and Scale

A notion of risk has been introduced. When in 1996 a UK laboratory demonstrated the suspected link between BSE in British cows and the rare and mortal brain disease in humans called vCJD (a variant of Creutzfeldt-Jakob Disease), the event provoked chain reactions all over the world. Apart from making headlines in most European newspapers and causing a worldwide ban on British beef, the event epitomizes what, in hindsight, may be seen as the emergence of both a new awareness of risk and an increased distrust in political institutions as key issues in public debates about food in Europe, and subsequently also in the US.[1] The case of BSE in Britain demonstrated for many that government officials could not be trusted (a picture of the then UK Minister of Agriculture feeding his daughter a beefburger to prove its safety was circulated widely across Europe). It also exposed how the beef industry, seeking to cut expenses, had used bovine meat in the production of feed for bovine animals, thus transgressing the rule that, until then, had largely remained unspoken, namely that herbivores should not be forced to feed on species of their own kind – a type of cannibalism. This practice might never have become public knowledge had it not been for the fact that temperatures used in feed production were turned down (another cost-cutting measure), thus allowing the prions causing BSE to migrate from contaminated carcasses to healthy cows and, in turn, across species boundaries to human consumers (Franklin, 1999). In this way, the case of BSE also became a vivid illustration of commercial greed, of inept food-safety authorities, untrustworthy politicians and a nature that, according to media coverage, had the ability to 'strike back'. Thus, in the case of BSE, the political implications of a food scandal have had significant and far-reaching consequences, even if the implications for human health are still being debated, as the number of people directly affected by vCJD is still relatively low (Zwanenberg and Millstone, 2003).

The BSE scandal came in the wake of other scandals, such as salmonella and dioxins in chicken, so that the 1990s may be seen to represent a historical watershed with regard to the way food is thought about, talked about and handled. Food is no longer simply a much-needed material resource; its purchase is now linked to the need for consumers to balance monetary concerns with issues of risk and distrust. What could previously be left to food safety authorities and nutrition expertise hit the headlines of the news media and became a topic of expert controversy and public debate. Where policy measures used to be dominant, a complex interplay of food producers, food control, state policies, news media and the public is now involved in defining food safety. As a result, 'what's for dinner?' has become an issue of considerable concern, demonstrated yet again in the most recent food scare about carcinogens in salmon sparked by a food safety report published in the US (see www.foodstandards.gov.uk/news/pressreleases/sciencesahiion). Food is politicized, not only as a commodity for consumption, but all the way into the kitchen and the dinner table, with implications for cooking and family care.

Genetic modification of food, which again hit the headlines in the 1990s, has meant that many of our most common foodstuffs can no longer be taken for granted. Since the emergence of GMOs on the food market, the material properties of food itself have become the subject of controversy. Some argue that genetic modification represents only a faster method of plant cultivation, and one with immediate benefits. Critics maintain that speed makes a difference, as it collapses qualitatively significant material changes into a time span of a few years that would previously only be noticeable over several generations. Such changes expose the malleability of edible substances, and force us to realize that the foods we eat are the result of human manipulation, often with unintended consequences. No longer trapped in a 'black box' of conventional (agri-) cultural practices (Latour, 1987), food is thus exposed as a hybrid phenomenon. As such, it immediately enters the battlefield of conflicting agendas and interests. In this way, the politics of food has come to be implicated in the very notion of food itself, what food is and what it should be.

Genetic engineering has implications far beyond its actual implementation. Even in Norway, where GMO foods are still marginal and essentially banned, public awareness of the options inherent in genetic engineering has opened the food debate toward new problem areas, and has thus politicized the very substance of food, even though our tomatoes are still more or less the same. In this way, the politics of food is no longer confined to policy making within the nation state, but closely connected to innovations and discourses that take place on the transnational arenas of science, technology and trade.

Food on Transnational Arenas

Food is increasingly involved in controversies at a transnational level. The global politics of food involves not only the unequal distribution of access and rigged producer markets, but also moral and political engagements in relation to what is seen by many as a single global environment (Franklin et al, 2000). In this way, the politics of food is also politics at a distance, as exemplified by consumer boycotts, internet petitions and other examples of global-environmental activism. Several factors constitute the background for this development. First, although the long-distance transport of food is far from new (cf. Pelto and Pelto, 1983; Mintz, 1985), the delocalization of food has become more significant during the last decades, leading to what some scholars refer to as the 'globalization of food and nutrition systems' (Sobal, 1999). Using the terminology of Held et al (1999) one may reasonably argue with regard to food that we have witnessed an increase both in the extensity of global networks, in the intensity and impact of global interconnectedness, and in the velocity of global flows. This implies that the potential impact of local events on distant affairs have become even more significant. This imbues some affluent consumers with a sense of responsibility for relations that are not only distant, but also extremely complex and hard to grasp, and thus brings world politics into the shopping cart. At the same time, as global consumers, we are vulnerable to shifts in practices, regulations and routines that take place in distant regions of the world. Negligence, fraud and adulteration represent sources of risk to most of us, even if they happen elsewhere, just as corporate decisions that are made in New York, or policy decisions made in Brussels, may have dramatic consequences for the access to food and livelihood in rural India.

This is just another way of saying that as food systems are globalized, food becomes entangled in complex webs of political significance. It does not, by itself, make food a political object, but it vastly increases the number of diverse interests, relations and regulatory frameworks that are enrolled as each food item makes its way from production through to consumption (Fine and Leopold, 1993). Hence, the potential for interests to diverge and come into conflict also rises exponentially, even if only a few of these conflicts ever surface on the political agenda of the public media.

In the case of food, therefore, its socio-political relations of production are always more significant than the food item itself might reveal. What appears to be a carrot or a piece of meat is indeed a product with a history and implications more complex and profound than most of us even want to think about. This gap between what we actually know about the food we eat and what we could potentially know (and even act upon), makes transparency a key issue. Thus, the politics of food is also a politics of silence and exposure, a quest for the power to control what will be declared, what will be the focus of public debate and what will remain unspoken (Nestlé, 2002). This issue has been in the forefront of the debate concerning GM food in Europe, where the issue of explicit and exhaustive labelling has brought European governments into conflict with the US. Transparency is also a key theme in the debate in the wake of the first diagnosis of BSE in a cow in the US in 2003 (cf. *The Guardian*, 12 January 2003; www.oie.int/eng/press/en_031224.htm).

The problem of safety and transparency is not new. It was the basis for the creation of regulatory systems for food control established as early as the 19th century. Yet, we argue that with more abstract relations[2] between producer and consumer, a weakening of expert authority (Beck, 1992) and frequent exposures of food 'scandals' in public media, consumers sense even more strongly the impossibility of being 'fully informed'. As a result of what is experienced by some as a 'knowledge deficit', the politicization of food is more than ever a selective process of choosing to highlight one particular issue out of myriad potential candidates. Since the list is almost endless, the question of which items to politicize becomes a political issue in itself.

At the same time, food is always locally embedded. The cultural, social and moral context for the provision and consumption of food is also a local context. Such local contexts filter which food-related issues are to surface on the public agenda, and provide a framework within which such issues are constructed, interpreted, discussed and solved. In other words, all novel developments, from the impact of foot-and-mouth disease (FMD) on the English countryside to new technologies of genetic engineering, are always understood in the light of relations and distinctions that are significant in relation to a local and familiar framework. Thus, the discovery of BSE in the Czech Republic resonated with the prominent ambivalence about East–West boundaries in the post-Soviet states, while the French campaign against GMO was absorbed in an anti-American, anti-globalization movement and expressed through promotion of French Roquefort. Similarly, the British debate about the 'foot-and-mouth' epidemic tapped into a pre-existing framework of urban consumer guilt about the greedy capitalist exploitation of the local countryside, while transnational anti-whaling campaigns draw upon Euro-American notions of individualism and family values to evoke sympathy for the whales. In this way, controversies that may appear at first to be part of a discourse that some scholars refer to as 'transcultural' (Milton, 1996, p170) turn out to be strongly embedded in values and distinctions that are, in fact, highly specific. Thus, in an era of so-called globalization, when it comes to food, the boundaries between local concerns and global affairs are not easily drawn.

Why Food?

Much of what has been said so far about transformed processes of production and globalized systems of provision could have been said about a whole range of material products, such as textiles, petroleum, hardwood, pharmaceuticals and more. Yet, several features make food a unique phenomenon, more profoundly absorbed in complex relations than any other product, and yet different from everything else. What is so special about food?

As a material substance with a crucial balance of nutrients and toxins, food has immediate biological implications. Unlike clothing, piercing, or body paint, food is literally transformed and becomes *part of* the human body. Thus, the saying 'you are what you eat', has several layers of meaning, from the symbolic to the material. But the absence of food has profound implications as well. The physiological need in humans to eat every day makes access to food a crucial issue, and has compelled human beings throughout history to develop social and technical systems of provision that aim to ensure stable food supplies through domestication, exploitation, reciprocity and trade. It also makes us vulnerable, weak and easy to control. In this way, food is entrenched in structures of subordination, governance and domination.

Second, as food and eating are routinized on an everyday basis, food becomes a convenient medium for the expression of social and ceremonial distinctions, and for naturalizing relations of community and hierarchy. As such, the symbolic meaning of food in any given context may be seen as sedimentation of historical structures of power and inequality that have been operating through generations (Bourdieu, 1979; Mintz, 1985). As a symbolic system of meaning, food is therefore both a structured and a structuring force.

Third, humanity's attempts to enhance bodily functions and abilities through scientific means have paved the way for what in the field of food is captured by the term 'nutritional science'. As nutrition has become one of the most significant fields of preventive medicine, it serves also as a structuring agent in relation to food choice. In this way, scientific nutrition advice may run contrary to agricultural interests (Kjærnes, 1993), food industry (Nestlé, 2002) and even national food and nutrition policies (Lien, 1990). In this way, connections between food and body also give rise to conflicts between policy interests, business and science.

The Legacy of Anthropology

As anthropologists have demonstrated since the inception of the discipline, food is a profound medium of reciprocity that marks and distinguishes persons and relations through acts of sharing, giving and receiving (Malinowski, 1922; Mauss, 1925). Add to this the significance of food in systems of classification (Leach, 1964; Douglas, 1966, 1975; Lévi-Strauss, 1970), the social organization of labour in food production (Richards, 1939; Evans-Pritchard, 1940), food in religious and healing rituals (Archetti, 1997), and the precarious interplay between the extraction of food resources and the environment (Rappaport, 1968), and we have a rough idea of the various ways in which food would make its way into holistically oriented anthropological monographs of the 20th century (for an overview, see Douglas, 1984; Murcott, 1988; Sutton, 2001). Food's importance as a social mediator, a cultural symbol and a natural resource is readily apparent in holistic studies of small-scale societies.

Yet, as anthropologists' attention shifted from small-scale exotic societies to post-industrial societies closer to 'home', the holistic approach has become more difficult to realize. At the same time, there has been a tendency toward analytical specialization through subfields since around the 1970s. Today, food is no longer an indispensable component of a social and cultural analysis. Rather, in more recent publications, food tends to be either the paramount topic of analysis, or hardly mentioned at all. Thus, the 'anthropology of food' has emerged as a distinct subdiscipline,[3] widely popular but often also somewhat detached from more general research issues. What we witness here is partly an attempt at cutting problems 'down to size' (such as 'food and gender', 'systems of provision', 'food production', 'food and risk', 'food consumption' and so on) in order to address urgent challenges in applied research, or to link food to topical concerns. However, as a result of such delineations, the complex entanglements that were the hallmark of more holistic anthropological accounts tend to be lost.

Furthermore, the way we choose to cut the problem down to size is often informed by the way we order and classify food generally, that is deeply entrenched in Western ways of thinking about and ordering the world. Certain Euro-American cultural distinctions have therefore – almost unnoticed – slipped into our theoretical apparatus and provided us with approaches to food that split apart dimensions of food that are, in fact, closely connected. Thus, broadly speaking, food is approached as either nature or culture, either production or consumption, either as an aspect of the private *or* the public domain. Although this is a common problem and difficult to escape, it is perhaps more problematic in the field of food than in other areas, because it often implies that we cut our analyses precisely at the most interesting junctions. As a result, the analytical possibilities inherent in the multiplicity of food, i.e. the analytical potential of food as a mediator between domains commonly set apart, is often lost.

What we need is not a return to meticulous accounts of villages as in the anthropological classics, but rather a re-evaluation of an underlying premise that has shaped the anthropological structure of inquiry: the fundamental assumption that relevant connections cannot be defined in advance, but emerge as a result of empirical research. This inductive approach lay at the heart of functionalist anthropology and went hand in hand with the holistic approach. Today, in an academic world already ordered by neat and sharp subcategories (risk, globalization, embodiment, etc.), a more holistic approach may seem impossible to achieve. Research projects must to be formulated in relation to culturally predefined domains, and food studies are no exception. Yet, I would suggest that precisely in this situation, more widespread intellectual disobedience in relation to the overarching categories would allow food studies to move a step forward. The degree of entanglement of a phenomenon can never be ascertained in advance, and this is especially the case in relation to food. In a world of global systems of provision, abrupt material transformations and complex layers of governance, most efforts at compartmentalizing food in accordance with predefined categories are bound to be too narrow. Malinowski claimed in 1922 that:

> An Ethnographer who sets out to study only religion, or only technology, or only social organisation cuts out an artificial field for inquiry, and he will be seriously handicapped in his work. (Malinowski, 1922, p11)

Malinwoski's advice to anthropologists in the early 1920s captures what could be seen as the most significant lesson to be learnt from anthropology in the field of food studies today: one who sets out to study food only as consumption, production, globalization, embodiment, nutrition, family life or economics is likely to be trapped by the same boundaries that structure the very field that she or he tries to illuminate. Fresh insight into contemporary dilemmas requires research that challenges such sectorial boundaries. I am proposing an approach to food which resists such preconceived distinctions and follows instead the connections that food allows humans to make. Just as Appadurai (1986) suggests we might study the 'social life of things', food may be followed through its various entanglements, across boundaries both legal and moral, beyond and between nations, bodies, persons and nutrients. If we do that, we will find that what appears as controversies about food often turns out to be controversies about something else.

Mary Douglas once said, referring to consumption more generally, that 'the essential function of [food] is its capacity to make sense' (Douglas and Isherwood, 1979, p40). I argue that the essential function of food is its capacity to make connections. Approached holistically, food effectively dissolves most preconceived distinctions between nature and culture, production and consumption, morals and markets, family and society, the individual and the collective, body and mind. At the same time, it remains a profound medium of reciprocity, constituting meaningful relationships at different levels and of different kinds. It is precisely through this capacity to make connections that food has become a highly charged political object.

To state that food is a political object is another way of drawing attention to the fact that many relations that are constituted by and through the medium of food are also power relations, and should be analysed as such. Our approach to power relations goes beyond, or even bypasses, a focus on the formal institutions of the state (Gledhill, 1994; Vincent, 2002). In light of the crisis of legitimacy characterizing political life in general, and the deregulation and liberalization currently affecting food in particular, a focus on policies, bureaucracies and politicians would simply be too narrow to grasp significant issues and changes. Politics, like food, is embedded in social practice, discourse, controversy and conventions that are not always labelled 'political'. Thus, our approach to the politics of food is based on the premise that 'action which contests existing power relations may take many forms', and that much of this is 'in constant danger of slipping from view, simply because of its everyday and inchoate quality' (Gledhill, 1994, p23). Drawing attention to some of the less obvious ways in which food is politicized, we seek to contribute to a more nuanced understanding of both politics and food.

Governmentality, Risk, Embodiment, Nature

What connections are illuminated through an empirical focus on food? Most issues below have been developed theoretically by other scholars and from other topical angles. They are included here because they are particularly relevant for analyses of contemporary power relations surrounding food.

One such connection is captured by the term governmentality (Foucault, 1991; Coveney, 2000) referring to the emergence in Europe of a concern for the governance of a complex of 'men and things' through a range of techniques for knowing about populations (statistical surveys, medicine, demography) and for managing populations through such knowledge. In the book *Food, Morals and Meaning*, John Coveney makes a powerful link between a Foucauldian concept of governmentality and the 20th-century discourse on food and nutrition, arguing convincingly that nutrition is:

> a government of food choice which situates the individuals within a field of knowledge for explicit objectives, and, at the same time, provides them with a way of constituting themselves as ethical subjects through a decipherment of their pleasures and fulfilments. (Coveney, 2000, p177)

Coveney's use of Foucault helps us to trace how food mediates relations between the state and the individual, or between the nation and 'its' human bodies. Most importantly, he demonstrates how governmentality in relation to food involves the socialization of family members as 'good' parents, 'good' children and 'good' citizens, and thus involves the construction of ethical subjects.

Another set of issues relevant to the study of food and social connections is captured by the recent emphasis on institutional reflexivity (Giddens, 1991), risk-society (Beck, 1992) and related terms like radical doubt, uncertainty and (lack of) trust. Although these descriptions of high modernity are somewhat eurocentric and hardly applicable on a global scale, they draw attention to a range of dilemmas that are strongly felt along the North Atlantic rim. Because they transcend the physical boundaries of the body, food and eating practices are highly sensitive to shifting configurations of risk and trust (Fine and Leopold, 1993). Furthermore, since what is harmful in food often escapes the senses (i.e. toxic substances cannot always be seen, smelled or tasted), trust in relation to food is abstract, involving social relations that are often distant, and often more imagined than real (Lien, 1997). Consequently, changing configurations in the relation between the state and its citizens, or between supplier and consumer, are likely to be expressed as uncertainty about food and risk. Similarly, as the case of BSE has shown, food scandals can bring about significant changes in the organization of safety regulations and systems of provision. In recent years, scientific authorities have been losing public trust. Although European countries differ greatly in this respect (Poppe and Kjærnes, 2003), there is a general trend in which science and experts no longer offer the sense of certitude they once did. One aspect of this 'post-enlightenment' turn is the transformed role of the media from that of being disseminators of expert knowledge to becoming virtual battlefields of conflicting expert claims. In this situation, the politics of food is also a 'politics of discourse' in which the power to set the public agenda, to frame the debate, and to silence opponents become a key resource. Such politics of discourse may be analysed as the strategic use of food metaphors, the distribution of blame and shame, and the role of the media in framing abstract risks in such a way that they are perceived as 'real' or relevant to ordinary consumers.

A third set of issues that emerge from the connections that food help us make relates to the sensory and experiential dimensions of food and eating. As an anchor of embodied experience, food often plays a key role in collective or individual acts of remembrance (cf. Karen Blixen's *Babette's Feast*, or Marcel Proust's account of 'La petite Madeleine'). David Sutton has explored these dimensions by drawing attention to the often ignored potential of food to evoke memory. In his book *Remembrance of Repasts* (Sutton, 2001), he makes a fine attempt to bridge the Cartesian dualism of mind and body by analysing food in a Greek village as both semiotics *and* embodied experience. Drawing on the works of Paul Connerton (1989) on commemoration and Thomas Csordas (1994) on embodiment, he demonstrates how worlds of experience and interpretation are contained in food. Here, we take this further, showing how eating as a commemorative act highlights the role of food in political conflicts regarding land claims and displacement of refugees. Food thus emerges as a material link that confirms and establishes, in a very sensual manner, the felt connections between a people and a place. Such connections reveal important nuances to the alleged ability of globalization to weaken ties of kinship and place (Eriksen, 2003). The fact that food politics is also body-politics has also been developed in other directions, through explorations of food and gender (Counihan and Kaplan, 1998; Counihan, 1999) and of food, body image and self-identity (Lupton, 1996).

Finally, a view of food as nature draws attention to the connections that are made between food and the natural environment, and between food and an idealized image of nature as opposed to culture and technology. Today, when science and technology can more than ever before refashion what we used to see as nature, the concept of nature appears to retain an even greater capacity to capture our imagination and to encapsulate notions of what is good, sound and true. Thus, even though the foods we consume are shaped, adjusted and manipulated by human intervention, references to nature abound in food advertising, culinary discourse and public debate (Lien, 1995, 1997). This obsession with nature affects the way we think about food both in relation to environments of production (e.g. organic farming methods), in relation to food products themselves (e.g. processed foods versus 'natural' foods), and in the way we envisage the way food shapes our body and health (e.g. popular 'Paleolithic' diets). We need to pay attention to a 'politics of nature' which, in contemporary discourse, goes beyond what is traditionally captured by the term environmentalism. As Macnaghten and Urry (1998) note, there is not one single nature, only a diversity of natures that are contested and constituted through a variety of social, cultural and political processes. When we envisage food and diets as more or less 'natural', or argue for schemes of production that are more (or less) sustainable or harmoniously adapted to our notions of nature, we latch on to these debates, and thus find ourselves in a field which is already highly charged with assumptions of a rather dubious kind. Bruno Latour (1987) offers a way out by suggesting a symmetrical approach in which nature and society are analysed on equal terms. In his analysis of modern practices of purification and translation between nature and culture (Latour, 1993), he provides us with a theoretical framework which is fruitful for understanding the hybrid nature of food, and its contemporary oscillation between the natural and cultural domains.

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Notes

1 We do not argue that BSE in the only factor contributing to this awareness – several other food scandals played a part. Nor do we argue that food distrust was caused by the BSE event in a straightforward manner; in the UK such distrust had in fact been 'simmering' for years. What we argue is that the case of BSE was significant, both in bringing about political change and in serving as a model for exposing controversies in media, even in countries that remained uncontaminated by the disease itself. In this way, it represents a case in which, afterward, things were never quite the same.

2 Abstract relations refers both to the distance, socially, culturally and spatially, between production and consumption, and to the processes of abstraction that characterize the ways in which suppliers and consumers are made apparent to each other (through market surveys, sales statistics, and through the emphasis on brand name at the expense of structures of ownership and agency in food production, cf. Lien, 1997).

3 This is exemplified by the development of nutritional anthropology as a distinct subfield in the US. In Europe, we find similar developments toward compartmentalization under the heading 'anthropology of food'.

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4

The System of Rice Intensification (SRI): A Challenge for Science, and an Opportunity for Farmer Empowerment Towards Sustainable Agriculture

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Introduction

Rice is the dominant staple food crop throughout Asia and is an important source of carbohydrate and fibre globally. In Asia alone, more than 2 billion people obtain 60–70 per cent of their calories from rice (FAO, 2004); and global demand is expected to rise by 38 per cent above the current production within 30 years (Surridge, 2004). No doubt the Green Revolution helped many Asian countries achieve food sufficiency, but it also degraded the environment and threatened agricultural sustainability (Pretty, 2002). Competition for land due to urbanization, an impending water crisis (Wopereis et al, 1994; Barclay, 2004), declining soil fertility, and overuse and misuse of harmful agrochemicals pose threats to production. At the same time, current technologies are approaching their limits (Horie et al, 2005) and are no longer sufficient to meet increasing demands with relatively shrinking natural resources. These considerations have generated a number of novel rice production management techniques, some of them overlapping. These include alternate wetting and drying (AWD) (Belder et al, 2002), aerobic rice culture (Bouman and Tuong, 2001), integrated crop management (Balasubramanian et al, 2004), use of controlled-release of fertilizer (Shoji and Kanno, 1994) and, more recently, the System of Rice Intensification (SRI) (Stoop et al, 2002). SRI, among these 'alternative' options, is currently perhaps attracting the greatest interest, and certainly the most controversy. The article in *Nature* (Surridge, 2004) acknowledged SRI's growing popularity

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and presented a review on its current status, reporting statements for and against. The 'SRI' coordinating website, managed by The Cornell International Institute for Food, Agriculture and Development (http://ciifad.cornell.edu/sri) provides an overview of the set of management practices that define SRI and documents what is happening globally with SRI, mainly at farmer's field level.

Many small-scale SRI farmers are witnessing phenomena that are entirely novel within their lifelong experiences. Individual rice plant, grown from both traditional and 'Green Revolution' improved varieties, are seen to respond to SRI growing conditions with unexpected increased vigour in three major areas – roots, vegetative parts and grain yield. These responses, at the individual plant level, are real. It has been found that improved varieties respond positively, usually better than traditional varieties, but the latter also have given some remarkable increases in yield and profitability (Koma, 2002; Anthofer, 2004).

In many cases, farmers are claiming that the positive responses at the individual plant level have translated into higher crop yields while reducing key inputs, in particular, seeds, synthetic fertilizers and water. Controversy surrounds particular aspects of these lower input claims: some say labour demands have increased, e.g. for weeding; some say unsustainable levels of organic matter are required; some argue that crop yields have been unrealistically extrapolated from small experimental plots.

It would be simplistic to say that the enormous gains achieved in rice production by the Green Revolution technologies have been entirely due to the development and use of certain genotypes that respond favourably to high inputs of synthetic fertilizers. But, to the extent that these two elements fuelled the Green Revolution, it created a path dependency which has demanded continual genetic improvements to maintain production levels, let alone increased production from limited land. It is also acknowledged that the Green Revolution, by increasing dependency on external inputs and alien technology, reduced the opportunity and incentive for farmers to manage their natural resources and make their own crop management decisions. In essence, the Green Revolution had tended to disempower rice farmers.

Biotechnology favours the notion that 'the solution lies in the seed' and gives renewed enthusiasm to supporters of the Green Revolution philosophy. It is not surprising that some of the Green Revolution scientists have dismissed SRI as an unnecessary distraction (Sheehy et al, 2004; Sinclair and Cassman, 2004; McDonald et al, 2006). Sinclair (2004) described SRI reports as an 'Agronomic UFO' (unidentified field observation); while Sheehy et al (2005) labelled SRI 'a flawed idea and nonsense curiosity'. These characterizations say more about the emotions SRI has generated than about scientific reasoning or investigation. The reality is that millions of smallholder rice farmers in developing countries are experiencing a wide gap between potential and actual farm yield (Papademetriou et al, 2000; Stoop and Kassam, 2005; McDonald et al, 2006). The gap has become manifest at a time when scientists are claiming that rice yield is approaching a limit.

This gap and current economic exigencies should be providing an incentive for farmers to explore the potential of novel options. Why is SRI attracting the lion's share of attention? SRI offers a set of management practices that farmers can evaluate, adapt and then adopt to meet their own local requirements, rather than adopt some preset package of practices. Moreover, it relies minimally on external inputs and maximally on farmers acquiring and using new knowledge. The FAO Community IPM programme in Asia (www.communityipm.org/) demonstrated the ability and willingness of rice farmers to become experts at growing a healthy crop. For example, these empowered farmers learned the merits of conservation biological control – exploiting local biodiversity to manage pests instead of the unnecessary use of synthetic pesticides – a process labelled 'informed non-intervention'(Gallagher et al, 2005). SRI provides farmers with a new set of options that create considerable scope for 'informed intervention' (Stoop et al, 2002); for example, careful, rapid and shallow transplanting of younger seedlings, that are more widely spaced and use less water. These interventions are counter-intuitive, given current practices and beliefs, and certainly grate with the guiding influence of a rich tapestry of traditions that go back many generations. However, empowered farmers, determined to increase production sustainably, are prepared to explore all aspects of SRI practices, mindful of local agronomic conditions. To the extent that SRI is and will continue to be a successful innovation, an explanation for SRI's apparent popularity lies in the central role played by farmers.

Proponents of SRI argue that there are synergistic effects among the recommended practices, giving more increase in yield when all are used together rather than when practices are used singly and separately. Some are dismissive of any 'reductionist' approach which entails teasing apart the individual and combined impacts of specific components of SRI on plant growth. However, the claimed synergistic effect of components of SRI practice rekindles some latent issues that are still not given adequate attention, by either 'opponents' or 'proponents' of SRI. One such critical issue is the contribution of root vigour towards yield. The evidence that SRI produce vigorous plants with larger root systems has been recognized (Dobermann, 2004; Stoop, 2005), but why roots can make so much difference to yield is not fully understood. Therefore, the contribution of rice roots to the grain yield demands research intervention as a priority.

This chapter looks into several important questions. What is the scientific basis for the observed responses by individual plants and resulting crop yields to SRI growing conditions? What are the important gaps in knowledge that need to be addressed so that the potential benefits/limitations from SRI can be realized/identified? And what are the respective and collective roles of farmers, trainers and researchers in filling the gaps?

Attention has been drawn to the 'hidden half' of the plant and to evidence that indicates that SRI management practices might be increasing 'root activity' for better yield performance. A large body of research, mainly from Asia, validates some of the claims of SRI. In particular, the four basic management practices (see below) of SRI that appear to enhance root activity have been focused on. An integrated model for a high-yielding rice plant, relevant to both traditional and improved varieties and based on optimal root activity, is presented below. A collaborative approach by researchers and farmers is also discussed, based on SRI methodology and sound science, to enable farmers to provide optimal growing conditions for rice production that is sustainable both ecologically and economically.

SRI and the High-Yielding Theory of Rice Production

SRI is defined as a set of basic management practices (Stoop et al, 2002; http://ciifad.cornell.edu/sri) that includes:

- transplanting very young seedling (10–15 days old);
- rapid and shallow transplanting one or two seedlings with wider spacing (30 × 30cm or 40 × 40cm);
- practising alternate wetting and drying (AWD) during the vegetative phase (or keeping the soil moist but not continuously saturated);
- applying compost in preference to chemical fertilizer.

The SRI concepts developed by Fr. Laulaniè in the 1980s in Madagascar (Stoop et al, 2002), have many similarities with an earlier production approach (Horie et al, 2005) called 'High-Yielding Theory' (HYT) (Matsushima, 1973; Table 4.1). HYT was a yield-increasing strategy, researched and practised in some Asian countries, but largely overlooked during the Green Revolution period.

The one feature that differentiates SRI and HYT is plant density. SRI strives to increase yield by maximizing yield per plant, whereas HYT pursues the same objective by increasing plant densities per hectare. In doing so, HYT did eventually pay some attention to root activity but this effort was focused on increasing the number of aerenchyma mainly by genetic manipulation (Lee, 1980). The rationale was to minimize lodging at later growth stages which was the most common problem for rice plants grown with HYT. Although there was evidence that the main compound which influences plant growth and development through root activity was cytokinin (Richmond and Lang, 1957), this useful piece of information was largely ignored until recently. In the late 1980s it was assumed that higher root activity can increase a plant's physiological efficiency; but this concept was mainly acknowledged as a future breeding strategy (Kumura, 1989). The reason for not pursuing root activity was fairly obvious, i.e. the factors enhancing and maintaining root activity at later growth stages were not fully understood and explored; and so remained untouched.

Only recent research has corroborated Richmond and Lang's (1957) earlier findings that the highly efficient photosynthetic performance of super high-yielding rice cultivars is largely due to the increased cytokinin content in their roots (Shu-Qing et al, 2004), contributing to higher grain yield. In addition, it has also been found recently that, by minimizing plant density by transplanting a single seedling per hill, root quantity and cytokinin content are enhanced in the rice plant at later growth stages. This results in increased grain yield per plant due to

Table 4.1 *Model for cultivation of an ideal rice plant based on High-Yielding Theory (HYT)*

Yield	Percent of ripened grains	×	No of grains per unit area
Six prerequisite for ideal rice plant	(1) Necessary and sufficient number of grains for obtaining the target yield	(2) Many short panicles with short culms for realizing prerequisite (1) (2) Short, thick and erect upper three leaves	(4) Leaf colour not faded even after heading (5) As many green leaves per culm as possible (6) Favourable weather conditions for 40 days (15 days before and 25 days after heading)
Growth period	<u>Early growth period</u> Up to the leaf number index 69	<u>Middle growth period</u> Leaf number index 69 to 92	<u>Late growth period</u> Leaf number index 92 and later
Main target for cultivation	Securing number of panicles (tillers)	Controlling plant type (improving light receiving efficiency) Preventing lodging Improving physical condition	(Increasing the percentage of ripened grains)
Cultivation practices	Raising healthy seedlings Early season planting Heavy application of nitrogen in such a way that the nitrogen supply can be restricted in the middle growth period Shallow transplanting Prevention of root damage Dense planting	Restriction on nitrogen supply* Midsummer drainage	Topdressing of nitrogen (at the late spikelet differentiation and full heading stages) Making the root healthy (intermittent irrigation) Abundant sunshine (heading at most sunny time)

Note: * Measures to restrict nitrogen supply must be taken mainly during the early growth period.

Source: Matshusima, 1973

enhanced physiological efficiency of the plant (San-oh et al, 2006). The practice of planting a single seedling per hill, and its impact on root activity is one of the unique and novel components that could be explored using SRI management.

Theory of Root Oxidation Activity

Before we discuss SRI management practices in relation to root activity, we need to review the physiology of root activity; and how it influences the physiology of the rice plant by enhancing photosynthetic efficiency.

Roots supply nutrients and water, synthesize plant hormones, anchor plants and interact with soil biota. The physiological activities of roots contribute to the reinforcement of their oxidation activity. Oxidation activity in roots is measured by a phenolic redox pigment, particularly ά-napthylamine, which is widely employed to assess root activity. Rice root respiration has a proportional relationship with ά-napthylamine-oxidizing activity (Yamada and Ota, 1958). The oxidation rate is greater in new roots compared to old ones (Aimi and Fuzimaki, 1959). Therefore, by root activity, we are mainly focusing on root respiration.

Rice roots follow an aerobic pathway like other plant parts, although the root environment under flooded cultivation is hypoxic. For this purpose, lysigenous intercellular spaces, called aerenchyma, operate as an oxygen supply route to the roots (Yamada and Iyama, 1953). It was shown that the development of lysigenous intercellular space varied greatly according to the growing period and environmental conditions (Yamada et al, 1954; Arikado, 1955). Initially, it was believed that root activity increases with increased number of aerenchyma (to the extent that oxygen is a limiting factor in respiration) (Arashi and Nitta, 1955); and the number of aerenchyma not only varies with the growing environment, but also varies with the rice growth stages itself. In general, it has been found that flooded rice has its peak root activity from the beginning to the middle heading period, whereas upland rice has a wider peak compared to submerged rice (Mitsui and Tensho, 1952). It was argued that by increasing the number of aerenchyma, root activity can be enhanced. But later it was found that upland cultivars with fewer aerenchyma had higher root activity compared to lowland cultivars (Puard et al, 1986). Further, it was discovered that in addition to the supply of oxygen provided mainly by aerenchyma, sugar content of roots also has a close relationship with root respiration rate and activity (Tsuno and Yamaguchi, 1987).

The supply of photosynthates or sugar to the roots is mostly done by the lower leaves (Tanaka, 1958). Therefore it was suggested that, to sustain high root activity, it is necessary that the rice plant's configuration allows sunlight to reach the lower leaves as much as possible. Thus, the suggestion emerged to keep the upper leaves erect for this purpose. In addition, it was also found that oxygen supply to the roots is also easier from lower leaves than from upper ones and that withered lowered leaves, especially at later growth stages, lose their ability to take up and pass on oxygen (Arikado, 1975). Consequently, it was considered essential to keep lower leaves alive as long as possible so as to provide roots with both photosynthates and oxygen (Arikado, 1975). Thus a healthy root function depends on the rate of respiration, sugar content and oxygen supply.

Therefore, when the rice plant, especially the upland cultivars that have fewer aerenchyma compared to lowland cultivars, is grown under continuously flooded conditions with dense planting pattern, it retards the function of lower leaves and so the root activity, resulting in >75 per cent root degeneration at the time when flooded rice plants commence flowering (Kar et al, 1974), i.e. at a time when peak root activity is required by plants to achieve higher yield. Also, the lower oxygen concentration in the rhizosphere and continuous soil submergence results in more accumulation of carbon dioxide around the roots which speeds up the root senescence.

Impact of Root Activity on Plant Physiology and Yield

The details of how a healthy root system influences the physiology of the 'visible' plant, especially how it affects yield, are discussed here. For the purposes of discussion, indicators for root health are defined as root mass and respiration rate. In general, factors listed as responsible for increasing the physiological efficiency of rice plants include: canopy architecture (Takeda et al, 1984); single leaf photosynthetic activity (Park and Ota, 1969; Hayami, 1983); root activity and root quantity (Lee, 1980; Jiang et al, 1985); and plant adaptability to pure stands or monoculture (Donald, 1968, 1981; Ishi et al, 1986). All these factors are closely dependent on root activity since higher ά-naphthylamine-oxidizing activity of roots is correlated with higher chlorophyll content of the leaves, slower leaf senescence (Ota and Lee, 1970; Youn and Ota, 1973), and more erect standing leaves.

These important findings reflect the causality in the relationship between above-ground and under-ground plant parts. Similarly, Jiang et al (1985) suggested that if root activity is kept high during the ripening period, leaf blades will maintain their upright posture; and they will also age more slowly, delaying both withering and declining photosynthetic activity. In addition, they also found that when root activity is high, the photosynthetic rate does not decline so much in the afternoon. Therefore, these authors concluded that keeping root activity high is very important to maintain the functioning of the source, i.e. higher photosynthetic efficiency of the leaves during the ripening period. The conundrum was how to do just that since HYT was based on the supposition that higher yields were dependent on higher plant densities, leaving little scope to reduce the root activity-inhibiting effects of shading. A partial solution was suggested by Matsushima (1973) – intermittent irrigation at later growth stages to stimulate root activity. Based on Matsushima's suggestion, Tsuno and Wang (1988) concluded that drained field conditions could induce higher root activity by enhancing root respiration and root revitalization, resulting in greater leaf area, higher photosynthesis activity and higher yield. Recently, these finding have been complemented by another two major findings, i.e. high root activity contributes to a higher photosynthetic rate (Osaki et al, 1997), and the growth of shoots is very much dependent on root growth (Nikolaos et al, 2000).

Another valuable clue regarding the importance of root growth derives from the suggestion of Xuan et al (1989) that root quantity, as well as root activity, are both required for raising yield. This suggestion came after the discovery by Terashima et al (1988) that a super high-yielding cultivar has larger root systems compared to other indigenous cultivars.

In general terms, a larger root surface area is associated with higher cation exchange capacity, and thus more nutrient uptake becomes possible. Further, greater root quantity also correlates with drought tolerance. Several research groups have shown that, in the case of drying soil, water deficits first appear near the surface and then progress to the deeper layers; increased depth of rooting is common under these conditions (Proffitt et al, 1985; Newell and Wilhelm, 1987). Thus, root systems can be enhanced (deepened) by lowering soil moisture status, during the vegetative stage, providing a buffer against drought conditions.

This finding is in agreement with earlier findings (e.g., O'Toole and Chang, 1979; Yoshida and Hasegawa, 1982) that those cultivars which are characterized by higher ratios of deep root weight to the weight of the above-ground plant parts have a higher drought-tolerance score. The force required to pull up rice seedlings from the paddy soil is correlated with root weight, root branching, and thick root number (O'Toole and Soemartono, 1981). Based on the relationship between root abundance and drought tolerance, Ros et al (2003) recently proposed seedling selection with higher shoot/root ratios as a means of increasing drought tolerance and yield.

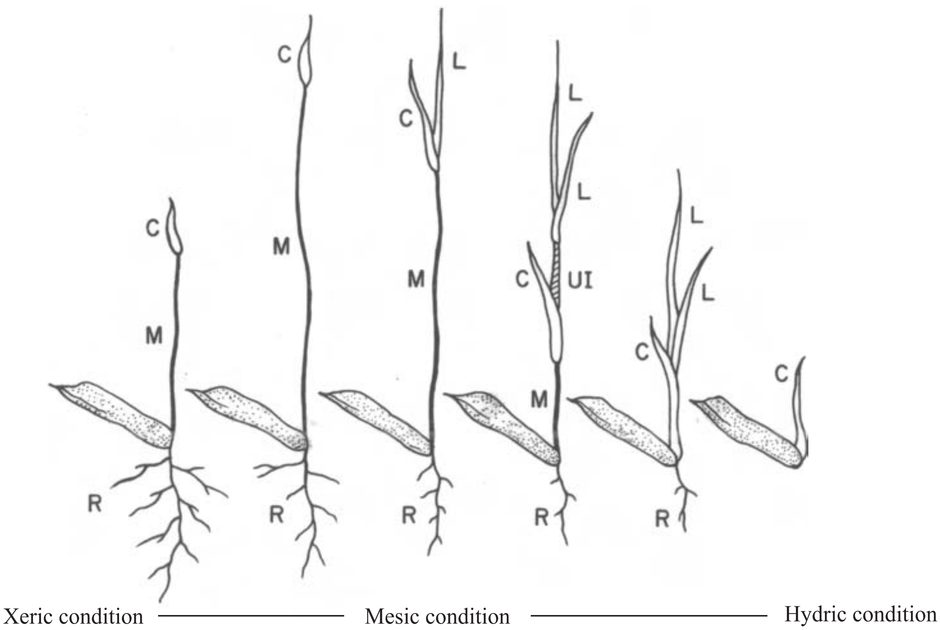
Thus there is abundant evidence to confirm the crucial role of the 'hidden half' plant parts in co-determining grain yield; this becomes all the more important when the crop needs to be managed under limited soil moisture conditions. However, despite these supporting facts, the importance of root activity in relation to yield has been given limited attention in rice research. One of the reasons for this oversight might be the dramatic success of the 'Green Revolution' which eclipsed, by and large, almost all traditional cultural practices in Asia, including HYT-based techniques. Perhaps it was also a case of out of sight, out of mind!

Only recently the 'half told' story of rice roots resurfaced when SRI practice became more widely known, when rice plants showed more vigorous root growth irrespective of cultivar species under SRI management. This indicates that the cultural practices recommended in SRI have an influence on root quantity and root activity and so provide the basis for reviewing basic management practices of SRI which might have an influence on root activity and quantity.

SRI Management and its Relation to Root Quantity and Activity

Growing seedlings in well-drained nursery beds with fewer seeds, and transplanting at the 2–3 leaf stage (germination and early seedling growth)

Although rice plants are 'semi-aquatic' and seeds germinate well in water (unlike true aquatic plants, the germination of rice is not inhibited by lack of oxygen), this does not mean that rice is an aquatic plant that grows better under submerged



2.69	2.35	1.40	1.30	0.75	
50	100	150	200	250	

Note: Where M = mesocotyl, C = coleoptile, R = root, L = leaf.

Equivalent values are shown between pF and percent scale: e.g. 2.69 is equivalent to 50% moisture content in the medium (vermiculite).

Source: Takahashi, 1978.

Figure 4.1 *Relationship between seedling growth and moisture content in a culture medium*

conditions. Many studies have examined the germination pattern of rice seeds under submerged conditions (Yokoi, 1898; Sasaki, 1926; Takei, 1941; Takahashi, 1978). These researchers have concluded that low oxygen tension in water caused elongation of coleoptiles and the prevention of radicle growth at initial stages. When Takahashi (1978) looked at the growth pattern of seedlings under different levels of moisture content in the media (Figure 4.1), he found that the elongated growth of the mesocotyl took preference over that of the coleoptile until near pF 2.4 (the forces necessary for plants to extract water from the soil for their use); then, as the pF was further lowered, coleoptiles growth occurred preferentially. No growth of the mesocotyl occurred under saturated condition. Takahashi (1978) reported that at lower oxygen tension in the water (as with hypoxic condition) compared to the atmosphere, several metabolites including carbon dioxide are accumulated in the surrounding root media and adversely affect seedling growth.

Similarly, Kordon (1974a, 1974b) reported that the primary and adventitious root growth was prevented by less oxygen in the root media.

Ros et al (2003) also showed that increased competition for nutrients at higher seed rates in the nursery bed reduced seedling vigour after transplanting. Based on these two facts it may be assumed that the SRI practice of maintaining well-drained soil in an SRI seed bed helps roots to grow at the very early seedling stage. At the same time, less inter-plant competition due to reduced seedling density helps seedlings access more growth-promoting nutrients, leading to healthier seedlings. Thus SRI seedlings are heavier and sturdier compared to seedlings grown in conventional nursery beds (Stoop, 2005).

Transplanting rice seedlings at a younger stage has been supported by many researchers (Ota, 1975; Yamamoto et al, 1995; Horie et al, 2005). This practice captures the benefit of the early phyllochron[1] stages (less than four leaves) having higher potential to produce more tillers/plant (Katayama, 1951). However, in the SRI method, special attention has also been given to careful uprooting and then gently transplanting seedlings immediately into the field with minimal root loss so as to minimize transplanting trauma. This practice makes an important contribution to subsequent root vigour and activity and hence to overall yield performance, compared to conventional management practices. In addition, SRI practice also suggests that the seed sac along with the soil attached to the seedling should be kept intact while uprooting to ensure that the endosperm is still attached, so that there is maximum sustained nutrition of the young plant. In general, uprooting causes stress to the seedling which could be minimized when the endosperm remains attached (Sakai and Yoshida, 1957; Ota, 1975; Hoshikawa et al, 1995).

In conventional management practice, it has been reported that around 40–60 per cent of the root remains in the soil during pulling up from the nursery. Pruning up to 60 per cent of the root during transplanting significantly decreased subsequent root and shoot dry matter (Ros et al, 1998). This suggests that a considerable loss of roots at the seedling stage affects seedling vigour and hence yield. Therefore, it may be suggested that SRI practices lead to increased shoot and root dry matter by protecting root systems during transplanting. SRI practices lead farmers to give greater attention to the conditions of growing, uprooting, storing, transporting and planting seedlings; and the effects that these practices have on plant development and yield.

One important factor that influences plant morphogenesis, and which has a profound influence on the formation of roots and shoots and their relative growth, is the level of cytokinin in the plant. As a phytohormone that is mainly synthesized in the roots, cytokinin has a significant effect on tiller bud formation (John et al, 1993; Bangerth et al, 2000); it mobilizes plant nutrients (Li et al, 1992), delays leaf senescence, regulates chloroplast development, and determines sink–source relationships (Hutchinson and Kieber, 2002).

Therefore, it may be assumed that SRI plants, at the seedling stage, that have more root quantity compared to conventionally grown rice seedlings, also have a greater supply of cytokinins. The implication of this for tiller development is discussed later. In addition, higher root quantity should enhance both nutrient and water-absorbing functions. This assumption is in agreement with the finding of Hanada (1976) where tiller bud formation was promoted by the application of kinetin to the rice roots at the five leaf stage.

In summary, careful transplanting at the 2–3 leaf stage should yield improved results as seedlings enjoy the benefit of both endosperm nutrition and of newly formed roots. However, careful and early transplanting requires increased skill, and hence labour; but once farmers realize that there is a set of options to evaluate in growing and transplanting seedlings that will have an impact on production and yield without heavy demands for costly inputs, rigid traditional practices will be seen in a new light.

Transplanting single seedlings with wider spacing

Plants grown with wider spacing have more area of soil around them to draw nutrients from. Such plants also have better access to solar radiation for better photosynthesis. Hence they perform better as individual plants. Consequently, there should be no mystery about why SRI plants invariably perform better than conventionally managed rice in terms of yield per plant. The reason for the deviation of this linearity in the case of grain yield per plot is that the yield is not entirely dependent on the performance of the individual plant. It is also a function of the total number of panicles per plot and on the other key yield-contributing parameters, number of filled grains per panicle and grain weight. Clearly, spacing is critical in modifying the components that influence final yield. In this regard, Takeda and Hirota (1971) showed that grain yield was unchanged between planting densities from 10 to 100 hills per m^2.

There is significant interaction between varieties and spacing. Generally, long-duration varieties do better with wider spacing than short-duration varieties (Baloch et al, 2002). This is in agreement with the recent finding of Stoop (2005) who suggested that long-duration varieties will perform better under SRI management practice. These responses support the hypothesis (Kira et al, 1953) that, with increasing planting density, biomass yield reaches a ceiling value that is limited by the supply of resources. The supply of resources mainly depends on the root system activity. So, it can be suggested that wider spacing allows roots to grow profusely along with production of more tillers per plant.

Under SRI management it can be suggested that early transplanting provides a longer vegetative growth period, and single seedling per hill reduces competition and helps to minimize the shading effect on lower leaves. This helps lower leaves to remain photosynthetically active, for much longer; and, in turn, root activity remains higher for a longer period due to the plant's enhanced supply of oxygen and carbohydrates to the roots (Tanaka, 1958; Horie et al, 2005). Further, higher root activity, in turn, supplies cytokinins to the lower leaves, delaying senescence and helping to maintain photosynthetic efficiency of the plant at later growth stages. This outcome has been confirmed by a recent research finding where single seedling per hill had higher yield compared to three seedlings per hill (San-oh et al, 2006). In addition, they reported that plants with one seedling/hill had greater numbers of crown roots, root length density and cytokinin content compared to plants with three seedlings/hill. The photosynthetic rate at later growth stages was significantly higher in single seedling/hill compared to three seedlings/hill.

However, single seedling/hill may be justified with the concept that the yield-contributing parameter within the plant can be modified by manipulating intra-hill interactions; still, inter-hill and row spacing need to be adjusted according to varietal characteristics (plant height, leaf area index, leaf posture and plant canopy area) to achieve optimum plant population per plot to realize higher yield potential under SRI management practices. Once again, farmers are well placed to experiment with spacing and its relation with varieties and crop yield. Increased spacing with younger seedlings runs counter to the traditional experiences of rice farmers and is one aspect of SRI that is approached with much scepticism by farmers who are experimenting with SRI concepts for the first time, with even more scepticism from neighbouring farmers. However, the impact of these practices on plant growth is sufficiently spectacular that neighbouring farmers start asking, 'what variety are you using?' Regardless of the eventual merits of SRI, it stimulates self-development and increased ownership by farmers of their production processes.

Intermittent irrigation

In recent years, the main aim of developing intermittent irrigation of rice has been to save water. It was reported that 25–50 per cent of water used could be saved by this method without any adverse effect on rice yield (Ramamoorthy et al, 1993; Tajima, 1995). In contrast, it has also been reported that intermittent irrigation increased water consumption and water stress, decreased leaf area index, induced early senescence and decreased the rate of photosynthesis and net assimilation rate (Lu et al, 2000). Recently, Belder et al (2005) have found that in aerobic rice culture, crop growth and yield was limited by water deficits and not by nitrogen deficiency. However, it was also found that growth is not harmed when plants are exposed to limited water conditions during their vegetative stage (Boonjung and Fukai, 1996). These authors concluded that the plant adopts osmotic adjustment at the vegetative stage which constitutes the most noticeable mechanism of dehydration tolerance in the rice plant (Steponkus et al, 1980). But, any drought stress at later stages in plants which are not exposed to such drying treatment can cause great loss, especially when plants are in the early reproductive phase (Kobata and Takami, 1981).

Interestingly, in HYT, intermittent irrigation served a different purpose. According to the HYT theory, the so-called 'broken irrigation' method was used to control tillering, improve soil conditions and to maximize efficiency at harvest by changing the sink–source relationship. The 'broken irrigation' method entailed the following procedure: after flooding the field, water intake was cut so as to let the water level go down gradually until the soil surface appeared, the field surface was exposed to air for three to five days, and then flooded again.

These findings indicate that intermittent drying in the vegetative stage may not only induce root growth into deeper soil layers but could also help the plant to develop xeromorphic characteristics. Intermittent drying also improves soil, stimulates tiller development and alters sink–source relationships. These findings are very illuminating for current rice production situations where various efforts are focusing on producing more food with less water.

In relation to root activity, it has been found that the three yield-improving components, that is, tiller development, soil condition and sink–source relations, have a close relation with cytokinin production which is regulated by root activity. It is greatly regulated by environmental conditions such as nitrogen availability, soil moisture condition, root mass, etc. Another phytohormone which is closely linked to nitrogen status of soil and may vary with the intermittent irrigation is auxin. Evidence exists that indicates that auxin induces lateral root formation while cytokinin helps in their elongation (Debi et al, 2005).

The hypothesis that cytokinin concentration is regulated by N (Kuiper et al, 1988) is supported by the positive relationship between N supply and cytokinin production (Mercier et al, 1997). It has also been indicated that production of cytokinin, as well as biomass, is stimulated by a mixed N source (NO_3^- : NH_4^+ ratio 1:1) (Wang and Below, 1996; Briones et al, 2003) rather than any single source. This statement is in agreement with the finding, reported by Kronzucker et al, (1999), that rice yields can be 40–60 per cent higher for any given amount of nitrogen taken up if the N is equally divided in forms between ammonium (NH_4) and nitrate (NO_3), rather than being entirely absorbed as ammonium. This synergistic mode of uptake is still poorly understood, but has been reported repeatedly in the literature (Ta and Ohira, 1981; Ta et al, 1981; Smiciklas and Below, 1992). Interestingly, hybrid rice cultivars, which tend to have higher root activity and quantity compared to traditional cultivars, are also more responsive to mixed sources of nitrogen (Luo et al, 1993).

A second important factor which influences cytokinin is soil nitrogen. The status and availability of soil N are dependent on the soil's aerobic/anaerobic environment. This influences the rate of N mineralization resulting from microbial decomposition of organic matter. In this context, it is reported that microbial decomposition responds to soil water content and to intermittent drying. The latter kills off a large portion of soil microbes, thereby releasing N for plant uptake during rewetting cycles (Birch, 1958; Bottner, 1985; Kieft et al, 1987). These findings indicate that soil nitrogen status may be enhanced, in terms of maintaining a balanced ratio of NO_3^- : NH_4^+ nutrition to enhance root-available nitrogen. These, in turn, regulate cytokinin, and therefore, root activity. NO_3^- increases the auxin:cytokinin balance required for tiller and biomass production, while urea and NH_4^+ shift this ratio in favour of cytokinin (Mercier et al, 1997), probably delaying root senescence at later growth stages. This is important in the context of SRI management practices where, after intermittent irrigation, shallow flooding has been recommended during the reproductive stage. This late flooding practice allows NH_4 to dominate, hence favouring cytokinin production.

A third component that affects cytokinin content is the root mass. It has been indicated that quantitative root growth is higher in high-yielding cultivars (Kim et al, 1985; Harada et al, 1988). These cultivars transport larger amounts of cytokinin to the above-ground parts of the plant during the ripening stage. This has the effect of suppressing a decline in rubisco content (Ookawa et al, 2004), resulting in a higher rate of grain filling and delayed senescence of the plant.

Since higher root mass is a greater supplier of cytokinin compared to fewer roots, there is evidence to indicate that intermittent irrigation may increase root mass during vegetative stages (Matsuki and Katsutani, 1940; Baba, 1977) and stimulates more root activity, and hence more cytokinin content. This favourable outcome can be achieved by maintaining higher rates of cytokinin production at a later growth stage, first by following intermittent irrigation during vegetative stage and then by maintaining shallow flooding during the reproductive phase. Clearly, this is not possible under completely flooded conditions because of the lesser quantity of roots and minimal root activity since, under continuously flooded conditions, over 75 per cent of roots degenerate by the time plants are entering their reproductive phase. (Kar et al, 1974).

This adaptive trait could be exploited to manage rice crops under limited water conditions without compromising grain yield. This could also be why farmers claim that they experience better yield with SRI practice compared to conventional production methods under drought conditions.

Application of compost

The fourth management practice of SRI is compost application. In general, plant root growth is greatly affected by the soil environment and, in this context, the effect of organic manure on soil is well known. The incorporation of organic manure into soil can bring beneficial effects to root growth by improving the physical and chemical environments in which roots grow (Sidiras et al, 2001; Yang et al, 2004). These non-biological aspects of the soil create a productive biological environment by stimulating root growth-promoting bacteria (Timmusk, 2003). In addition, the effectiveness of organic manure in improving root growth and nutrient uptake by rice plants is significantly different under different water regimes. For example, continuous water logging significantly decreases root growth (Sahrawat, 2000), whereas under intermittent irrigation, the incorporation of organic matter improves root morphological characteristics and root activity of rice plants. It has the effect of increasing root density, active absorption area, root oxidation ability and nutrient uptake (Yang et al, 2004).

There are immense benefits from compost application in rice farming given that compost improves the soil's physical, chemical and biological properties. And, therefore, it is not surprising that SRI recommends application of compost. However, the question of compost availability for large areas needs to be addressed.

First, it is clearly stated that application of compost in SRI practice is optional (http://ciifad.cornell.edu/sri/proc1/sri_03.pdf), even though some proponents of organic production present SRI otherwise (Schiller, 2004). This flexibility indicates that the observed positive SRI responses are not entirely based on organic fertilizer as it is assumed by some SRI critics (Sinclair and Cassman, 2004). However, in the past, agricultural utilization of organic materials was the common traditional practice in Asia when rice was produced and consumed locally. But, more recently, widespread introduction of chemical fertilizers together with the high costs of labour and transport of organic manure, plus diminished availability of biomass in some or many places, has led to a decline in the use of organic materials in cropping systems. At the same time, intensification of crop production and urban concentration have led to a large increase in the production of agricultural waste in many regions of the world. As with other grain crops, rice production is now more akin to an open-cycle extractive industry, driven by externally supplied synthetic inputs with nutrients being transported to urban concentrations, ultimately ending up as displaced pollutants. And in the absence of effective recycling procedures, the remaining crop residues are often mismanaged, leading to further nutrient loss.

The promotion of compost application in SRI serves two purposes: for farmers, it draws attention to the vital importance of soil structure and biology in growing a healthy crop sustainably; and for governments, it highlights the need to address the bigger question of returning nutrients to the rice paddy from the urban concentrations once the grain has been consumed and discarded as human waste. SRI advocates argue that the more extensive root systems of SRI plants and the improved soil structure and biology, induced by compost applications, provide access to a much larger pool of nutrients (Uphoff, 2003). To the extent that these claims are valid, they only provide a breathing space until agricultural production systems return to the closed cycle practised with traditional rice production.

Moving Ahead from HYT to SRI

It has been revealed that SRI management practices for rice production in Asia have strong linkages with the previous cultural practices such as HYT. Of course, SRI-inspired farmers appreciate the considerable savings in labour and seed costs, if they can reduce seedling density without compromising on yield. But why is SRI proving more successful in spreading than HYT, whose success was limited to a few farms where farmers could access large amounts of compost?

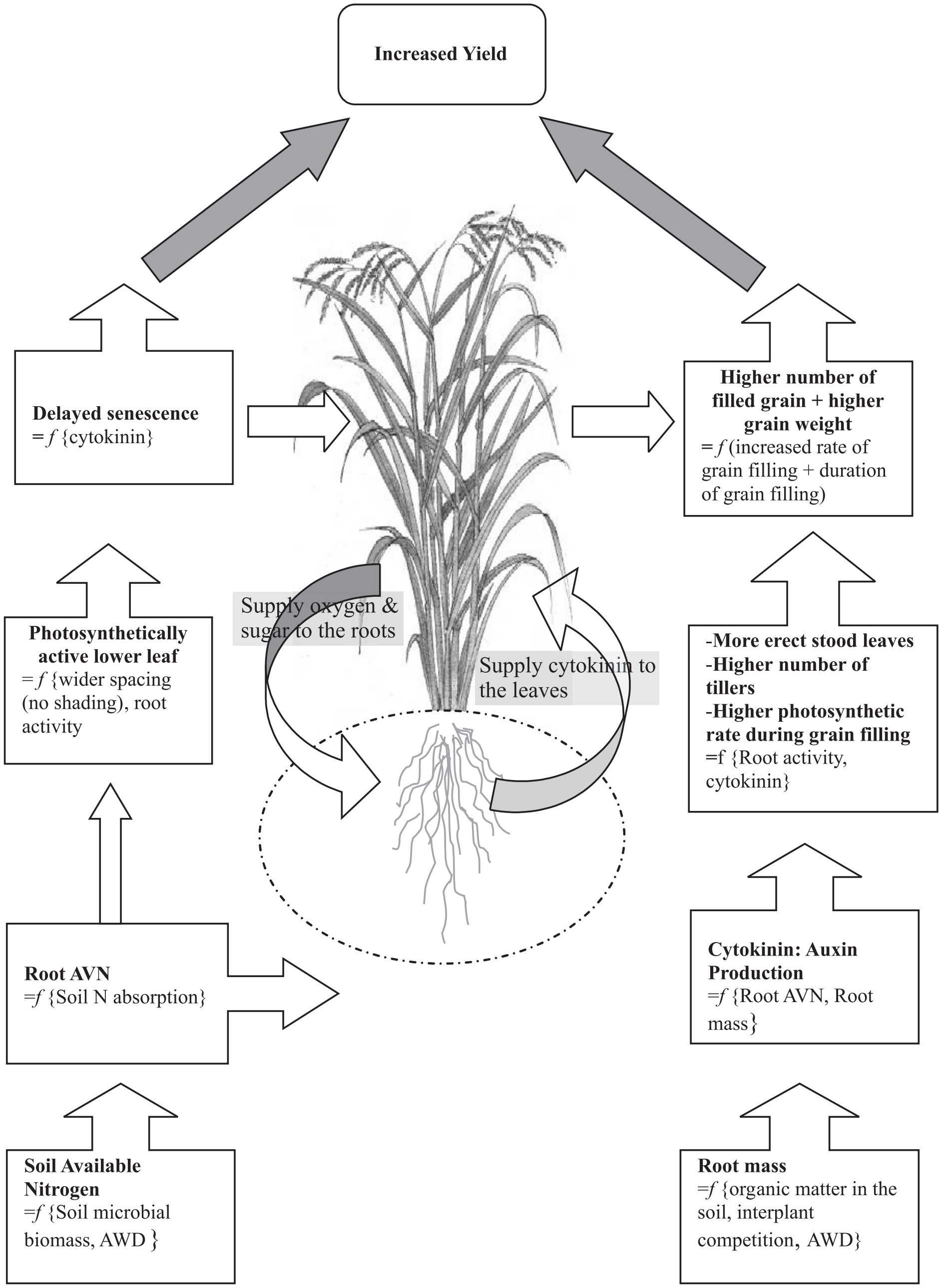
Matsushima (1973) suggested that in adopting HYT for high yield, the first step is to prepare a large ‘container’ and second is to fill this container with rice. By ‘container’ he means the number of spikelets per square metre, and the content of the container is the percentage of ripened grains. For the first step he suggested that there should be dense planting to secure the maximum number of tillers per square metre, and hence in turn the greatest number of grains per square metre. To achieve this, he suggested that the plant should absorb as much as nitrogen as possible without compromising plant health. Since lodging – and thus reduced photosynthesis capacity – at a later stage was the major constraint, he also added that improvement should also be made in the light-receiving efficiency of the rice crop. For this, he suggested revitalizing the roots by intermittent irrigation at later growth stages to increase root longevity. The idea was that this would prevent lodging and improve the physical condition of the plants by restricting their nitrogen absorption during the middle growth period while it will also help to maintain root function at later growth stages.

However, it proved extremely difficult for the growers to properly manage high plant density rice crops without lodging. And hence, just as there were a number of successful cases, there were various studies reporting failure also. Failures in securing sufficient number of grains per unit area explained most of the disappointing results (Kumura, 1989). This occurred mainly because of the unfavourable growth of the crops during the early growth period where plants were not able to absorb as much nitrogen as is required for achieving sufficient grains per unit area. It was based on the fact that the number of grains per square metre is in direct proportion to the amount of nitrogen absorbed by the rice plants per square metre during the late spikelet differentiation stage, and so a higher number of grains could not be achieved unless the plant is made to absorb much nitrogen. Therefore, without efficient promotion of root growth in early growth periods, high yields could not be realized. The latter provides a basis to support the SRI view that seedling vigour with healthy roots is important, and why sparse planting is needed along with intermittent irrigation during the vegetative period in order to realize the high yield potential of the rice plant.

The above presented review on root activity and quantity provides enough evidence to suggest that the physiological efficiency of the plant is improved by enhancing cytokinin activity, first by increasing root quantity and activity; second, by increasing root longevity; and third, by regulating available soil nitrogen status.

An Integrated Model of High-yielding Rice Plants Under SRI Management Practices

The above review and interpretation allow us to propose the following integrated SRI model of the rice plant with appropriate emphasis on optimal root activity (Figure 4.2).



Note: All variables are shown as functions (*f*) of the variables that drive them. (AVN = available nitrogen, AWD = alternate wet and dry).

Figure 4.2 *Integrated model of the high-yielding rice plant under SRI management practices*

Younger seedlings with higher root–shoot ratio encourage root–shoot growth along with higher rates of cytokinin synthesis

A most important crop production objective during the early growth period is to secure the optimum number of tillers per square metre. Tiller production and panicle development (at later growth stage) is related to cytokinin synthesis in the root along with the number of phyllochrons of growth completed.

Transplanting single seedling per hill further enhances root growth and root activity when grown with AWD during the vegetative period

To realize the full potential of tiller development, it is necessary to improve the light-receiving efficiency of the plant, prevent lodging and to improve the physical condition of the plant. This could be enhanced by further root growth and activity (1) by minimizing inter-plant competition and (2) by reducing leaf area density which will ensure more erect and upstanding leaves without any shading effect. At the same time, AWD will encourage root growth into deeper layers of soil. This will maximize the roots' surface area for better nutrient uptake. Greater root length will also minimize water stress should the plant be exposed to drought conditions during any period of crop growth.

AWD enhances microbial response and regulates the most available nitrogen forms in the rhizosphere

AWD should balance the NO_3:NH_4 ratio in the rhizosphere with higher root length density for higher biomass production and should also regulate cytokinin-auxin production for better tiller development. This effect could be further enhanced when the soil has sufficient organic matter to reduce leaching loss of NO_3 along with higher root growth at deeper layers of soil.

Shallow flooding during the post-anthesis period maintains higher cytokinin content with higher root activity

Cytokinins are high nitrogen-demanding compounds so cytokinin production increases sharply during high root nitrogen events which could be induced by supplying the NH_4 form of nitrogen by shallow flooding during the grain-filling stage. This would be better realized with higher root surface area and higher cation exchange capacity as high root nitrogen events result from increased root absorption of nitrogen from the soil as well as mobilization of stored nitrogen in the rhizosphere.

Higher root growth and activity increase physiological efficiency of the rice plant

Prolonged photosynthetic efficiency of the lower leaves could be maintained by avoiding shading between plants and by keeping root activity high during later growth stages. In turn, the photosynthetically active lower leaves would provide sugar as well as oxygen to maintain high activity of the roots during the later growth period.

Discussion

There is sufficient documented evidence to suggest that integration of the four key management practices of SRI could produce better on-farm yields compared to conventional production methods through improving the physiological efficiency of the rice plant. Therefore, one can challenge the contrary argument of McDonald et al (2006) that there is no correlation between these four practices and the physiological efficiency of the rice plant. Further, a careful review of the existing agronomic literature confirms that SRI practices have a sound scientific base (Horie et al, 2005).

High-yielding varieties (HYVs) and hybrid cultivars which are highly responsive to chemical fertilizers can have a clear place in SRI. Anthofer (2004) suggested that modern varieties also respond positively to SRI practices. SRI-grown plants show higher root growth (Stoop, 2005), but, interestingly both HYVs and hybrid rice do have higher root growth and activity compared to traditional varieties (Harada et al, 1988; Ookawa et al, 2004). These issues need to be addressed and investigated by systematic research focusing on varietal responses to SRI practices, particularly on root growth and its relation to yield.

Further, it seems reasonable to infer from a wide body of relevant research that all four SRI management practices have synergistic effects on root growth. However, a greater opportunity for productivity gains exists by using just the two major components that have attracted the greatest interest of thousands of farmers in Cambodia (Anthofer, 2004), i.e. using less seed and less water by planting single seedlings per hill with wider spacing and intermittent irrigation. In this context, giving emphasis to growing and transplanting vigorous seedlings singly is more pertinent than simply recommending planting single seedlings. Seedling vigour with minimal root disturbance needs to be taken into consideration along with seedling age in order to realize higher yield potential. Little differences in yield were found between SRI and conventional management practices in the three Chinese trials that Sheehy et al (2004) reported. This is an important finding since in both practices single seedlings were transplanted. Fortunately, there is now evidence that a single seedling per hill increased yield compared to three seedlings per hill. This effect was due to higher root growth and root activity which delayed senescence and increased the rate of photosynthesis at later growth stages (San-oh et al, 2006).

Further Sheehy et al (2004) reported fewer panicles per square metre in SRI than with conventional production methods. This accords with our claim that hill spacing needs to be decided according to varietal characteristics, most notably tillering capacity. This factor may be one of the reasons for yield variation observed under SRI practices either at the same or different locations.

The second major component that many farmers can adopt is water management according to SRI principles. It is evident from the literature that AWD, or intermittent irrigation, is already a component of water management practices of Asian rice-growing countries such as China, Japan and Korea. AWD is currently being evaluated and promoted among rice farmers producing in water-limited environments (Bouman and Tuong, 2001). But, in general, traditional practices focus on intermittent irrigation at later growth stages (Matsushima, 1973; Sheehy et al, 2004), while SRI recommends AWD at the vegetative stage. Certainly, in the latter case, due to a temporary drying effect at early growth stages, plants would develop with osmotic adjustment and develop more roots at a deeper soil layer. This root induction practice at the early vegetative stage may be useful for plants grown under limited water conditions such as aerobic rice cultivation where water stress has been found to be a more limiting factor than any other stress. It has been found that under these situations, water stress reduces crop nitrogen demand (Belder et al, 2005*)* and hence yield is significantly reduced. However, temporary drying through intermittent irrigation also affects soil nitrogen status by changing nitrification–denitrification and/or ammonia volatilization processes. This can lead to more nitrogen loss compared to completely flooded conditions, especially in soils with low organic matter.

Research opportunities lie in the measurement of redox potential at increased depths in the soil. This information may explain the pathway of nitrogen transformation processes in situations where deep root systems might get an advantage of transformed nitrogen (ammonium form) in the deeper soil layer, i.e. under a reduced soil environment. Moreover, if the AWD/intermittent irrigation practice at the vegetative stage is integrated with the split dose of nitrogen at crucial growth stages, this may overcome many limitations of aerobic rice culture and intermittent irrigation practice.

Apart from this, changing the soil status from aerobic to anaerobic by practising AFD (alternate flooding and drying naturally) three–four times during the vegetative stage can improve plant type, light-receiving ability and resistance to lodging, along with root health. But again it is important to consider when and how long the intermittent irrigation should be applied to save water as well as increase yield since rice root–shoot responses and their physiology also differ at the genetic level along with environmental factors. Certainly, these scientific considerations of SRI principles and related research questions offer opportunities for further studies.

Reported cases where SRI plants performed no better than best management practices, as claimed by critics of SRI, cannot be ignored (Sheehy et al, 2004; Latif et al, 2005). In this context, we note that Stoop and Kassam (2005) contend that neither SRI advocates nor its critics have a complete understanding of the biophysical basis of the relatively higher yields. It is noted that (e.g. McDonald et al, 2006) there is a wide yield gap between farmer's practice and best management practice. However, realization of the 'on-farm management issues', by both groups, is the most important outcome from the current debate on 'SRI'. The 'miracle' is not so much that SRI *practices* can lead to exceptional yield performances – we believe this is explicable from the existing literature – but that the *process* of investigating 'SRI' encourages farmers and researchers to think seriously, and as partners, about how to grow a healthy crop sustainably. The phenomenon of SRI should help the research community reach the millions of small farmers in developing countries to meet the future rice demand. We need a new paradigm in technology generation and transfer, and SRI seems to be promoting this outcome.

The primary focus and challenges of the past were mainly to increase food production; but the present scenario is quite different. The challenges are multifold where food production has to be increased by countering other challenges such as global warming, water scarcity, soil fertility degradation and misuse and overuse of farm chemicals. At the same time, social changes and a growing concern for the environment have brought about a recognition of the 'multifunctionality' concept (Molden et al, 2000). The quality and quantity of all the products embracing 'multifunctionality' depends on how the farmers treat them with confidence and appreciation. Modern agricultural research often focuses more on increasing productivity per se and ignores social externalities; it is largely built on technologies that maximize biological uniformity and ignores the natural ecosystem. Certainly, this approach is not optimal for managing sustainable production systems. Hence it demands a paradigm shift in technology development and adoption. Millions of smallholder farms in developing countries where SRI is showing promise reflect the importance of involving farmers in such activities. This requires a participatory approach to knowledge creation and innovation such as Farmers Field Schools (FFS) to empower farmers as experts in growing healthy crops efficiently in an economic and sustainable manner (Whitten and Settle, 1998). The success to date of the 'SRI movement' where it competes with the best available technology justifies applying these cooperative approaches for mitigating food demand without relying too heavily on imported technology

Conclusion

The combination of cultural practices recommended in SRI increases the physiological efficiency of rice plants through enhanced root activity and provides many alternatives to enhance resource-use efficiency. There is a sound basis in the existing literature which allows us to put SRI in scientific purview; but the practical constraints in managing a favourable interaction of the plant–soil environment should not be underestimated. However, these constraints could be minimized if SRI is used as a heuristic vehicle for linking rice research with participatory farmer empowerment programmes. The SRI movement should be seen as a unique opportunity to integrate science with the society for sustainable development. Moreover, SRI should be seen as a means of enhancing system productivity and not merely as a vehicle for increasing yield.

Note

1 Phyllochron – a periodicity in plant growth expressed as the number of days to complete a unit of growth which produces one or more phytomer (the unit of plant growth in gramineae species, consisting of a leaf and subtending internode with a tiller bud at its base) (Stoop, 2005).

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5

The Struggle to Govern the Commons

Thomas Dietz, Elinor Ostrom and Paul C. Stern

In 1968, Garrett Hardin[1] drew attention to two human factors that drive environmental change. The first factor is the increasing demand for natural resources and environmental services, stemming from growth in human population and per capita resource consumption. The second factor is the way in which humans organize themselves to extract resources from the environment and eject effluents into it – what social scientists refer to as institutional arrangements. Hardin's work has been highly influential[2] but has long been aptly criticized as oversimplified.[3–6]

Hardin's oversimplification was twofold: he claimed that only two state-established institutional arrangements – centralized government and private property – could sustain commons over the long run, and he presumed that resource users were trapped in a commons dilemma, unable to create solutions.[7–9] He missed the point that many social groups, including the herders on the commons that provided the metaphor for his analysis, have struggled successfully against threats of resource degradation by developing and maintaining self-governing institutions.[3,10–14] Although these institutions have not always succeeded, neither have Hardin's preferred alternatives of private or state ownership.

In the absence of effective governance institutions at the appropriate scale, natural resources and the environment are in peril from increasing human population, consumption and deployment of advanced technologies for resource use, all of which have reached unprecedented levels. For example, it is estimated that 'the global ocean has lost more than 90% of large predatory fishes' with an 80 per cent decline typically occurring 'within 15 years of industrialized exploitation'.[15] The threat of massive ecosystem degradation results from an interplay among ocean ecologies, fishing technologies and inadequate governance.

Inshore fisheries are similarly degraded where they are open access or governed by top-down national regimes, leaving local and regional officials and users without sufficient autonomy and understanding to design effective institutions.[16,17] For example, the degraded inshore ground fishery in Maine is governed by top-down

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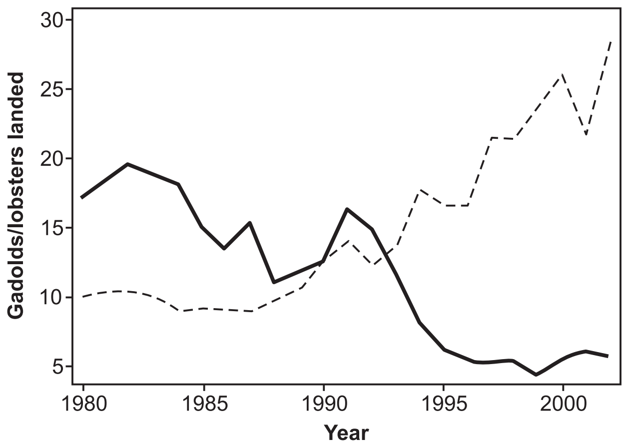


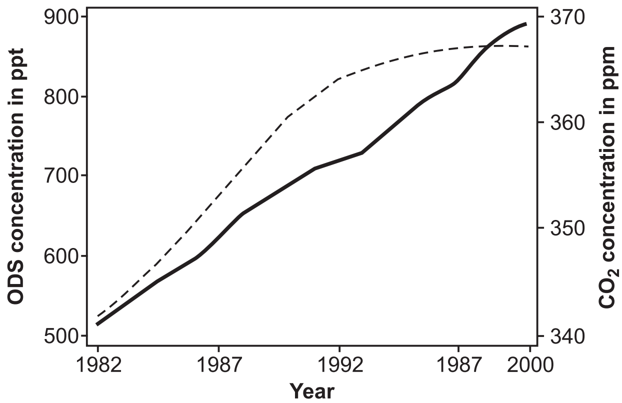
Source: See note 167

Figure 5.1 *Comparison of landings of groundfish (gadoids, solid line) and lobster (dashed line) in Maine from 1980 to 2002, measured in millions of kilograms of groundfish and lobsters landed per year. International fishing in these waters ended with the extended jurisdiction that occurred in 1977*

rules based on models that were not credible to users. As a result, compliance has been relatively low and there has been strong resistance to strengthening existing restrictions. This is in marked contrast to the Maine lobster fishery, which has been governed by formal and informal user institutions that have strongly influenced state-level rules that restrict fishing. The result has been credible rules with very high levels of compliance.[18–20] A comparison of the landings of groundfish and lobster since 1980 is shown in Figure 5.1. The rules and high levels of compliance related to lobster appear to have prevented the destruction of this fishery but probably are not responsible for the sharp rise in abundance and landings after 1986.

Resources at broader scales have also been successfully protected through appropriate international governance regimes such as the Montreal Protocol on stratospheric ozone and the International Commission for the Protection of the Rhine Agreements.[21–25] Figure 5.2 compares the trajectory of atmospheric concentrations of ozone-depleting substances (ODS) with that of carbon dioxide since 1982. The Montreal Protocol, the centrepiece of the international agreements on ozone depletion, was signed in 1987. Before then, ODS concentrations were increasing faster than those of CO_2; the increases slowed by the early 1990s and the concentration appears to have stabilized in recent years. The international treaty regime to reduce the anthropogenic impact on stratospheric ozone is widely considered an example of a successful effort to protect the global commons. In contrast, international efforts to reduce greenhouse gas concentrations have not yet had an impact.

Knowledge from an emerging science of human–environment interactions, sometimes called human ecology or the 'second environmental science',[26,27] is revealing which characteristics of institutions facilitate and which undermine sustainable



Note: *ppt* = parts per trillion; *ppm* = parts per million.

Source: Data are from note 169

Figure 5.2 *Atmospheric concentration of* CO_2 *(solid line, right scale) and three principal ODS (dashed line, left scale). The ODS are chlorofluorocarbons (CFCs) 11, 12 and 113 and were weighted based on their ozone-depleting potential*[168]

use of environmental resources under particular conditions.[6,28] We know most about small-scale ecologies and institutions whose many successes and failures have been studied for years. Researchers are now developing a knowledge base for broader-scale systems. In this chapter, we address what science has learned about governing the commons, how adaptive governance can be implemented and why it is always a struggle.[29]

Why a Struggle?

Devising ways to sustain the Earth's ability to support diverse life, including a reasonable quality of life for humans, involves making tough decisions under uncertainty, complexity and substantial biophysical constraints as well as conflicting human values and interests (Box 5.1). Devising effective governance systems is akin to a co-evolutionary race. A set of rules crafted to fit one set of socio-ecological conditions can erode as social, economic and technological developments increase the potential for human damage to ecosystems and even to the biosphere itself. Furthermore, humans devise ways of evading governance rules. Thus, successful commons governance requires that rules evolve.

Effective commons governance is easier to achieve when (i) the resources and use of the resources by humans can be monitored, and the information can be verified and understood at relatively low cost (e.g. trees are easier to monitor than fish, and lakes are easier to monitor than rivers);[30] (ii) rates of change in resources, resource-user populations, technology, and economic and social conditions are

Box 5.1 *Fish moved by warming waters*

Mason Inman

Climate change has fish populations on the move. In Europe's intensively fished North Sea, the warming waters over the past quarter-century have driven fish populations northward and deeper, according to a study by conservation ecologist John D. Reynolds of the University of East Anglia in Norwich, UK, and his colleagues. Such warming could hamper the revival of overfished species and disrupt ecosystems, they assert. The warming is expected to continue in the North Sea, and although fish species living to the south will likely move north and replace departing ones, the forecast for the region's fisheries will depend on whether the species that succeed are marketable.

'This is another clear indication that warming is playing a role' in ocean ecosystems, says physical oceanographer Ken Drinkwater of the Institute of Marine Research in Bergen, Norway. Although there have been many studies looking at the effects of climate change on marine species, 'no one has looked in detail at changes in distributions of commercial and noncommercial species', says fish biologist Paul Hart of the University of Leicester in the UK. Similar climate-induced shifts in fish populations, he adds, might happen in other temperate seas, including those around Europe and much of the US.

The study used extensive records of fishing catches made by research vessels between 1977 and 2001, a period during which the North Sea's waters warmed by 1°C at the sea floor. Reynolds's team cast a wide net, compiling data on the sea's 36 most common bottom-dwelling fish. They found that two-thirds of the populations moved toward cooler waters – either going north or to deeper waters, or both. 'We saw shifts in both commercial and noncommercial species, and across a broad set of species', says conservation ecologist Allison Perry of the University of East Anglia. The fish species whose distribution have shifted tend to be smaller and mature earlier, she and her colleagues noted.

Source: *Science*, Vol. 308, no 5724–5937, 13 May 2005

moderate;[31–33] (iii) communities maintain frequent face-to-face communication and dense social networks – sometimes called social capital – that increase the potential for trust, allow people to express and see emotional reactions to distrust, and lower the cost of monitoring behaviour and inducing rule compliance;[34–37] (iv) outsiders can be excluded at relatively low cost from using the resource (new entrants add to the harvesting pressure and typically lack understanding of the rules); and (v) users support effective monitoring and rule enforcement.[38–40] Few settings in the world are characterized by all of these conditions. The challenge is to devise institutional arrangements that help to establish such conditions or, as we discuss below, meet the main challenges of governance in the absence of ideal conditions.[6,41,42]

Selective Pressures

Many subsistence societies present favourable conditions for the evolution of effective self-governing resource institutions.[13] There are hundreds of documented examples of long-term sustainable resource use in such communities as well as in more economically advanced communities with effective, local, self-governing rights, but there are also many failures.[6,11,43–45] As human communities have expanded, the selective pressures on environmental governance institutions increasingly have come from outside influences. Commerce has become regional, national and global, and institutions at all of these levels have been created to enable and regulate trade, transportation, competition and conflict.[46,47] These institutions shape environmental impact, even if they are not designed with that intent. They also provide mechanisms for environmental governance (e.g. national laws) and part of the social context for local efforts at environmental governance. Broader-scale governance may authorize local control, help it, hinder it or override it.[48–53] Now, every local place is strongly influenced by global dynamics.[49,54–58]

The most important contemporary environmental challenges involve systems that are intrinsically global (e.g. climate change) or are tightly linked to global pressures (e.g. timber production for the world market) and that require governance at levels from the global all the way down to the local.[49,59,60] These situations often feature environmental outcomes spatially distant from their causes and hard-to-monitor, broader-scale economic incentives that may not be closely aligned with the condition of local ecosystems. Also, differences in power within user groups or across scales allow some to ignore rules of commons use or to reshape the rules in their own interest, such as when global markets reshape demand for local resources (e.g. forests) in ways that swamp the ability of locally evolved institutions to regulate their use.[61–63]

The store of governance tools and ways to modify and combine them is far greater than often is recognized.[6,64–66] Global and national environmental policy frequently ignores community-based governance and traditional tools, such as informal communication and sanctioning, but these tools can have significant impact.[64,67] Further, no single, broad type of ownership – government, private or community – uniformly succeeds or fails to halt major resource deterioration, as shown for forests in multiple countries.[68]

Requirements of Adaptive Governance in Complex Systems

Providing information

Environmental governance depends on good, trustworthy information about stocks, flows and processes within the resource systems being governed, as well as about the human–environment interactions that affect those systems. This information must be congruent in scale with environmental events and decisions.[49,69] Highly aggregated information may ignore or average out local information that is important in identifying future problems and developing solutions.

For example, in 2002, a moratorium on all fishing for northern cod was declared by the Canadian government after a collapse of this valuable fishery. An earlier near-collapse had led Canada to declare a 200-mile zone of exclusive fisheries jurisdiction in 1977.[70,71] There was considerable optimism during the 1980s that the stocks, as estimated by fishery scientists, were rebuilding. Consequently, generous total catch limits were established for northern cod and other groundfish, the number of licensed fishers was allowed to increase considerably and substantial government subsidies were allocated for new vessels.[72] What went wrong? There were a variety of information-related problems, including that fisheries managers (i) treated all northern cod as a single stock instead of recognizing distinct populations with different characteristics, (ii) ignored the variability of year classes of northern cod, (iii) focused on offshore-fishery landing data rather than inshore data to 'tune' the stock assessment, and (iv) ignored inshore fishers who were catching ever-smaller fish and doubted the validity of stock assessments.[72–74] This experience illustrates the need to collect and model both local and aggregated information about resource conditions and to use it in making policy at the appropriate scales.

Information also must be congruent with decision makers' needs in terms of timing, content and form of presentation.[75–77] Informational systems that simultaneously meet high scientific standards and serve ongoing needs of decision makers and users are particularly useful. Information must not overload the capacity of users to assimilate it. Systems that adequately characterize environmental conditions or human activities with summary indicators – such as prices for products or emission permits, or certification of good environmental performance – can provide valuable signals as long as they are attentive to local as well as aggregate conditions.[78–80]

Effective governance requires not only factual information about the state of the environment and human actions but also information about uncertainty and values. Scientific understanding of coupled human–biophysical systems will always be uncertain because of inherent unpredictability in the systems and because the science is never complete.[81] Decision makers need information that characterizes the types and magnitudes of this uncertainty, as well as the nature and extent of scientific ignorance and disagreement.[82] Also, because every environmental decision requires trade-offs, knowledge is needed about individual and social values and about the effects of decisions on various valued outcomes. For many environmental systems, local and easily captured values (e.g. the market value of lumber) have to be balanced against global, diffuse and hard-to-capture values (e.g. biodiversity and the capability of humans and ecosystems to adapt to unexpected events). Finding ways to measure and monitor the outcomes for such varied values in the face of globalization is a major informational challenge for governance.

Dealing with conflict

Sharp differences in power and in values across interested parties make conflict inherent in environmental choices. Indeed, conflict resolution may be as important a motivation for designing resource institutions as is concern with the resources themselves.[83] People bring varying perspectives, interests and fundamental philosophies to problems of environmental governance;[76,84–86] their conflicts, if they do not escalate to the point of dysfunction, can spark learning and change.[87,88]

For example, a broadly participatory process was used to examine alternative strategies for regulating the Mississippi River and its tributaries.[89] A dynamic model was constructed with continuous input by the Corps of Engineers, the Fish and Wildlife Service, local landowners, environmental groups and academics from multiple disciplines. After extensive model development and testing against past historical data, most stakeholders had high confidence in the explanatory power of the model. Consensus was reached over alternative governance options, and the resulting policies generated far less conflict than had existed at the outset.[90]

Delegating authority to environmental ministries does not always resolve conflicts satisfactorily, so governments are experimenting with various governance approaches to complement managerial ones. These range from ballots and polls, where engagement is passive and participants interact minimally, to adversarial processes that allow parties to redress grievances through formal legal procedures. They also include various experiments with intense interaction and deliberation aimed at negotiating decisions or allowing parties in potential conflict to provide structured input to them through participatory processes.[91–95]

Inducing rule compliance

Effective governance requires that the rules of resource use are generally followed, with reasonable standards for tolerating modest violations. It is generally most effective to impose modest sanctions on first offenders and gradually increase the severity of sanctions for those who do not learn from their first or second encounter.[40,96] Community-based institutions often use informal strategies for achieving compliance that rely on participants' commitment to rules and subtle social sanctions. Whether enforcement mechanisms are formal or informal, those who impose them must be seen as effective and legitimate by resource users or resistance and evasion will overwhelm the commons governance strategy.

Much environmental regulation in complex societies has been 'command and control'. Governments require or prohibit specific actions or technologies, with fines or jail terms possible to punish rule breakers. If sufficient resources are made available for monitoring and enforcement, such approaches are effective. But when governments lack the will or resources to protect 'protected areas' such as parks,[97–99] when major environmental damage comes from hard-to-detect 'nonpoint sources', and when the need is to encourage innovation in behaviours or technologies rather than to require or prohibit familiar ones, command and control approaches are less effective. They are also economically inefficient in many circumstances.[100–102]

Financial instruments can provide incentives to achieve compliance with environmental rules. In recent years, market-based systems of tradable environmental allowances (TEAs) that define a limit to environmental withdrawals or emissions and permit free trade of allocated allowances under those limits have become popular.[78,101,103] TEAs are one of the bases for the Kyoto agreement on climate change.

Economic theory and experience in some settings suggest that these mechanisms have substantial advantages over command and control.[104–107] TEAs have exhibited good environmental performance and economic efficiency in the US Sulfur Dioxide Allowance Market intended to reduce the prevalence of acid rain[108,109] and the Lead Phasedown Program aimed at reducing the level of lead emissions.[110] Crucial variables that differentiate these highly successful programmes from less successful ones, such as chlorofluorocarbon production quota trading and the early EPA emission trading programmes, include (i) the level of predictability of the stocks and flows, (ii) the number of users or producers who are regulated, (iii) the heterogeneity of the regulated users, and (iv) dearly defined and fully exchangeable permits.[111]

TEAs, like all institutional arrangements, have notable limitations. TEA regimes tend to leave unprotected those resources not specifically covered by trading rules. For example, fish species caught as by-catch are often not covered.[112] These regimes also tend to suffer when monitoring is difficult. For example, under the Kyoto Protocol, the question of whether geologically sequestered carbon will remain sequestered is difficult to answer. Problems can also occur with the initial allocation of allowances, especially when historic users, who may be called on to change their behaviour most, have disproportionate power over allocation decisions.[78,113] TEAs and community-based systems appear to have opposite strengths and weaknesses,[113] suggesting that institutions that combine aspects of both systems may work better than either approach alone. For example, the fisheries tradable permit system in New Zealand has added co-management institutions to complement the market institutions.[103,114]

Voluntary approaches and those based on information disclosure have only begun to receive careful scientific attention as supplements to other tools.[64,79,115–118] Success appears to depend on the existence of incentives that benefit leaders in volunteering over laggards and on the simultaneous use of other strategies, particularly ones that create incentives for compliance.[79,118–120] Difficulties of sanctioning pose major problems for international agreements.[121–123]

Providing infrastructure

The importance of physical and technological infrastructure is often ignored. Infrastructure, including technology, determines the degree to which a commons can be exploited. The extent and quality of water systems determine how they distribute water, for example, and fishing technology has a decisive influence on the size of the catch. Infrastructure also determines the extent to which waste can be reduced in resource use, and the degree to which resource conditions and the behaviour of human users can be effectively monitored. Indeed, the ability to choose institutional arrangements depends in part on infrastructure. In the absence of barbed-wire fences, for example, enforcing private property rights on grazing lands is expensive, but with barbed wire fences, it is relatively cheap.[124]

Effective communication and transportation technologies are also of immense importance. Fishers who observe an unauthorized boat or harvesting technology can use a radio or cellular phone to alert others to illegal actions.[125] Infrastructure also affects the links between local commons and regional and global systems. Good roads can provide food in bad times but can also open local resources to global markets, creating demand for resources that cannot be used locally.[126] Institutional infrastructure is also important, including research, social capital and multi-level rules, to coordinate between local and broader levels of governance.[49,127,128]

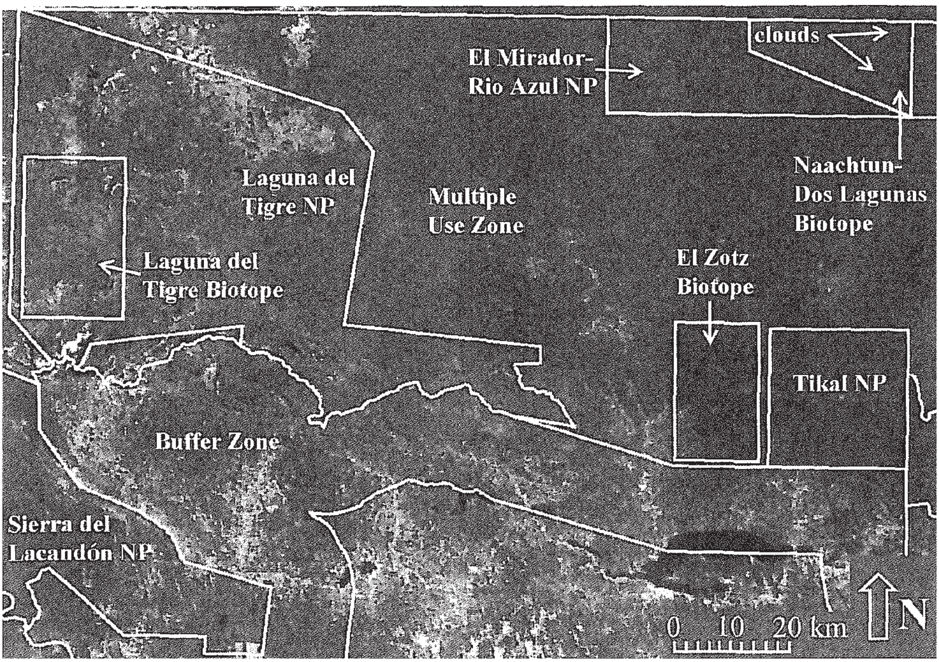
Be prepared for change

Institutions must be designed to allow for adaptation because some current understanding is likely to be wrong, the required level of organization can shift, and biophysical and social systems change. Fixed rules are likely to fail because they place too much confidence in the current state of knowledge, whereas systems that guard against the low-probability, high-consequence possibilities and allow for change may be suboptimal in the short run but prove wiser in the long run. This is a principal lesson of adaptive governance research.[29,32,129]

An Illustration of the Challenge of Inducing Rule Compliance

Meeting these requirements is always a challenge. We illustrate by focusing on the problem of inducing rule compliance and comparing the experience of four national parks, three different biological communities and a buffer zone contained within a single, large and very famous biosphere reserve – the Maya Biosphere Reserve (MBR) in Guatemala.[130] MBR (Figure 5.3) was created in 1990 by government decree to protect the remaining areas of pristine ecosystems in northern Guatemala.[131] The region saw a marked advance of the agricultural frontier in the 1980s resulting from an aggressive policy of the central government to provide land to farmers from the south.[132] MBR occupies over 21,000km^2, equivalent to 19 per cent of the Guatemalan territory, and represents the second-largest tract of tropical forest in the Western Hemisphere, after the Amazon.[133] Much of the territory within the reserve has been seriously deforested and converted to agriculture and other uses. Figure 5.3 shows examples of several governance strategies and outcomes within MBR,[134] but we concentrate here on two protected areas that have interesting institutional differences.

Tikal National Park is one of few protected areas in Guatemala to receive the full support of the government. The revenue from entry fees paid by tourists covers the entire budget for the park plus a surplus that goes to the Ministry of Culture and Sports. Directors of the park are held accountable by high-level officials for the successful protection of this source of government revenue. The park has permanent administrative and support staff, paid guards and local residents hired to prevent forest fires. Although Tikal National Park is in better shape than many other parks,[135] it faces multiple threats, especially from bordering communities in the form of forest fires ignited to transform the land for agricultural and livestock purposes and illegal extraction of forest products.[136] The dark grey colour of the park in Figure 5.3 shows the areas of stable forest.



Source: Composite constructed by Glen Green, Edwin Castellanos and Victor Hugo Ramos.

Figure 5.3 *This figure shows land-cover change and the numerous zones of the Maya Biosphere Reserve in northern Guatemala. The composite shows a uniform, dark grey colour within Tikal, indicative of stable forest cover. El Mirador-Rio Azul National Park and Naachtun-Dos Laguna Biotope are also stable, due to inaccessibility. The other four potected areas have experienced extensive inroads of deforestation shown in light grey and white. Official designation as a protected area is not sufficient unless substantial investments are made in maintaining and enforcing boundaries*

Laguna del Tigre National Park and Biotope are managed by two different conservation agencies and include the largest protected wetland in Central America. The principal threats are human settlement and immigration, encroaching agriculture and livestock, oil prospecting and drilling, construction of roads and other infrastructures, and lawlessness (e.g. intentional setting of forest fires and drug trafficking and plantations). Like Tikal, Laguna del Tigre has been designated for the highest possible level of government protection. However, land speculation inside and outside the park and biotope, fuelled by cattle ranchers, corrupt politicians, and other officials, has pushed illegal settlers deeper into the reserve, where they clear tree cover to establish new agricultural plots and homesteads. Numerous light gray patches within the park and biotope in Figure 5.3 reveal forest clearing.[137] Oversight in Laguna del Tigre has been weak. The small and underpaid group of park rangers is unable to enforce the mandates assigned to them to protect the park from human settlements, illegal harvesting and forest fires, and to sanction those who do not comply. It has not been unusual for people accused of violating conservation laws to threaten park officials to the point where the latter are afraid to enforce the law.

The Guatemalan cases illustrate that legally protecting threatened areas does not ensure rule compliance, especially when non-compliance is easy or profitable. Further illustrations of the roles of institutions in forest protection are discussed in *Science* supplemental online materials[68] and in a new book.[138]

Strategies for Meeting the Requirements of Adaptive Governance

The general principles for robust governance institutions for localized resources (Figure 5.4) are well established as a result of multiple empirical studies.[13,40,139–148] Many of these also appear to be applicable to regional and global resources,[149] although they are less well tested at those levels. Three of them seem to be particularly relevant for problems at broader scales.

Analytic deliberation

Well-structured dialogue involving scientists, resource users and interested publics, and informed by analysis of key information about environmental and human–environment systems, appears critical. Such analytic deliberation[76,150–152] provides improved information and the trust in it that is essential for information to be used effectively, builds social capital, and can allow for change and deal with inevitable conflicts well enough to produce consensus on governance rules. The negotiated 1994 US regulation on disinfectant by-products in water that reached an interim consensus, including a decision to collect new information and reconsider the rule on that basis,[76] is an excellent example of this approach.

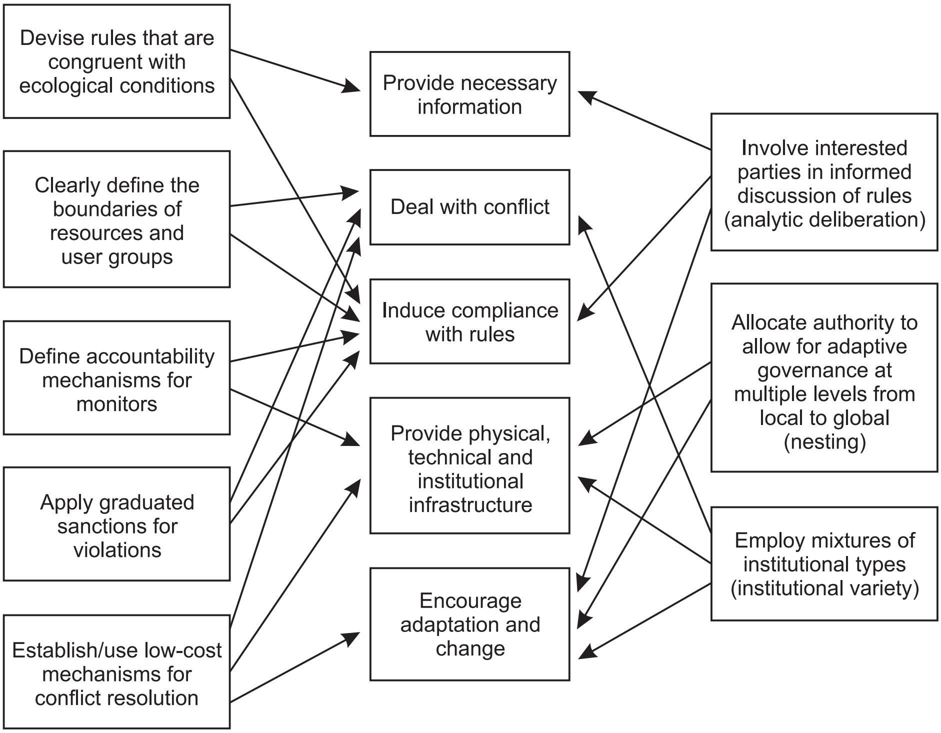


Figure 5.4 *General principles for robust governance of environmental resources (left and right columns) and the governance requirements they help meet (centre column).*[13,170] *Each principle is relevant for meeting several requirements. Arrows indicate some of the most likely connections between principles and requirements. Principles in the right column may be particularly relevant for global and regional problems*

Nesting

Institutional arrangements must be complex, redundant and nested in many layers.[33,153,154] Simple strategies for governing the world's resources that rely exclusively on imposed markets or one-level, centralized command and control and that eliminate apparent redundancies in the name of efficiency have been tried and have failed. Catastrophic failures often have resulted when central governments have exerted sole authority over resources. Examples include the massive environmental degradation and impoverishment of local people in Indonesian Borneo;[97] the increased rate of loss and fragmentation of high-quality habitat that occurred after creating the Wolong Nature Reserve in China;[155] and the closing of the northern cod fishery along the eastern coast of Canada, which is partly attributable to the excessive quotas granted by the Canadian government.[72] Governance should employ mixtures of institutional types (e.g. government bureaus as well as markets and community self-governance) that employ a variety of decision rules (about when and what resources should be harvested by whom) to change incentives, increase information, monitor use and induce compliance.[6,64,119] Innovative rule evaders can have more trouble with a multiplicity of rules than with a single type of rule.

Conclusion

Is it possible to govern such critical commons as the oceans and the climate? We remain guardedly optimistic. Thirty-five years ago it seemed that the 'tragedy of the commons' was inevitable everywhere not owned privately or by a government. Systematic multidisciplinary research has, however, shown that a wide diversity of adaptive governance systems have been effective stewards of many resources. Sustained research coupled with an explicit view of national and international policies as experiments can yield the scientific knowledge necessary to design appropriate adaptive institutions.

Sound science is necessary for commons governance, but not sufficient. Too many strategies for governance of local commons are designed in capital cities or by donor agencies in ignorance of the state of the science and local conditions. The results are often tragic, but at least these tragedies are local. As the human footprint on Earth enlarges,[156] humanity is challenged to develop and deploy understanding of broad-scale commons governance quickly enough to avoid the broad-scale tragedies that will otherwise ensue.[172]

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Part II

Poverty and Hunger

6

Words and Ideas: Commitment, Continuity and Irreversibility

R. Chambers

All words are pegs to hang ideas on (Henry Ward Beecher, 1887).

Part 1 presents writing on settlement schemes in tropical Africa from the late 1960s and early 1970s. Part 2 reviews subsequent developments with settlement schemes, and then explores and develops wider contemporary meanings, relevance and applications for three words and ideas from the earlier experience: commitment, continuity and irreversibility.

Part I: Learning from Experience

In the 1950s and 1960s, settlement schemes were conspicuous in tropical Africa. Many of them were politically committing and effectively irreversible. Once settlers had been introduced they were difficult to abandon. Schemes considered failures became robust dependent survivors. Many arguments could be mustered to justify continuing support, although this was often at high financial cost to governments. The Perkerra Irrigation Scheme in Kenya was one such project which by almost any criteria should never have been started, and once started, not continued. It performed disastrously but became increasingly difficult to abandon. In project appraisal, the political irreversibility of commitment is a neglected aspect of risk, and varies by type of project.

Introduction: Settlement schemes in tropical Africa (2004)

In the sub-Saharan Africa of decolonization and early national independence, much prominence was given to agricultural settlement schemes. They seemed to promise win–win solutions to political demands, perceived pressures of population, and the need to produce more from the land. With many origins, taking many forms, having high political priority, and being bounded and visible, they were attractive to

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researchers. I was one of those who succumbed to the temptations they presented. I started my research on the fragile and vulnerable Perkerra Irrigation Settlement in Kenya, and then concentrated on its stronger sibling, Mwea. The Mwea Irrigation Settlement had several advantages. It was by most criteria more successful; it had a stable water supply and in irrigated rice a reliable crop and a protected market; it was better organized; it had a high profile and was frequently visited, being a convenient distance from Nairobi for VIPs;[1] and, for the indolent PhD student it had the advantage of being well documented, with time series tables which could (I hasten to add, with due acknowledgement) be transposed easily to make a thesis look good, at least to any examiner too pressed for time to look deeply. Many researchers were attracted to Mwea, and the managers were so interested and articulate that we were able to combine to produce a book with 13 chapters and 529 pages (Chambers and Moris, 1973).[2]

In parallel, numerous studies of settlement schemes were undertaken in other countries, especially Sudan, Zimbabwe (Southern Rhodesia as it was), Zambia (Northern Rhodesia as it was), Tanzania, Uganda, Nigeria and Ghana. These provided a wonderful collection for comparisons. Much of what was learnt is now of mainly historical interest. However, analysis at the time pointed to three neglected angles or themes which were important then and remain important and still relatively neglected: commitment, continuity and irreversibility. The two extracts of studies from this period, which follow, raise practical questions not only about projects, but also about policies and programmes promoted and pursued by lenders, donors and governments in the 2000s.

Conclusions from *Settlement Schemes in Tropical Africa* (1969)

Risks and irreversibility of commitment[3]

A neglected aspect of evaluation, which has far wider application than merely to settlement schemes, concerns the relationship between risks and irreversibility of commitment.

Settlement schemes, especially those that are more complex in system and costly in capital, are high-risk undertakings. They share with non-settlement approaches to agricultural development the uncertainties of innovations, weather, pests and markets, and the disruptions of rapid turnovers in senior staff. In addition, however, they have to face other serious risks and difficulties which do not have to be borne in non-settlement situations. The land on which settlement takes place may be available for settlement for the simple reason that it is marginal or unsuitable for cultivation. The locations of many settlement schemes, often with poor communications and far from the services of urban centres, raise costs and the difficulties of management. There is a danger that both organizational and productive effectiveness will be restrained by the inbuilt incompatibilities of complex schemes, by the cancelling out of managerial and settler efforts, in the games of enforcing and beating the system. Moreover, adaptations of schemes to ensure the continued presence and participation of settlers may have to be made through increased payouts or through services which, at best, reduce revenue to government and, at worst, add to a loss. In addition, where government withdrawal is intended, there is a high risk that it will take longer than expected. At the point at which implementation of a settlement scheme or programme is considered, all these factors, all of them implying economic risks, should be weighed.

But these risks do not present the complete picture. Wherever a government starts a programme or project the actual risks are compounded by the extent to which the commitment to maintain the programme or project is irreversible. The process of commitment can be lengthy, subtle and insidious. It begins with an opportunity and a vision. These may arise from a disturbance in the relationships of men[4] and land, or the perception of unoccupied land: the Mwea (in Kenya), inviting development after the Kenya Land Commission's recommendations; the bush of South Busoga (in Uganda) after its evacuation in the first decade of this century; the narrow strip of uncultivated land on the edge of the Rift Valley at Upper Kitete (in Tanzania); the cleared bush of Kongwa, Urambo and Nachingwea after the Groundnut Scheme fiasco (in Tanzania). Or the opportunity may be provided by a resettlement operation which presents a captive population which can be directed into a new agricultural system: the displacement of Halfawis by the Aswan Dam, (in Sudan) was exploited through resettlement on the controlled irrigation scheme at Khasm-el-Girba; and the evacuees from the Volta Lake were thought to provide 'a unique opportunity to wean an appreciable proportion of Ghana's farmers from the wasteful, fragmented, and shifting system of agriculture to a settled and improved pattern of farming'.[5]

The opportunity attracts and nourishes the idea of a scheme. In such conditions a personal commitment can develop in a man of vision like Simon Alvord in Rhodesia or Chief Akin Deko in Nigeria. Funds are obtained for surveys: the surveys that are carried out are themselves committing. Where their findings are marginal, as was the United Nations Special Fund survey of the proposed Tana Irrigation Project in Kenya,[6] further investigations are called for. It becomes increasingly difficult to turn back. Once funds have been made available for a substantive scheme, the successive activities of planning, construction, settlement and production draw after them deeper and deeper personal, departmental and political commitments. The establishment of settlers sets a seal on commitment at a higher level, making abandonment extremely difficult and the use of protective political arguments extremely easy. The full repertoire of defences to ensure scheme or programme survival can now be brought into play. Moreover, officials and politicians in circumstances such as these may regard government funds as fair game, as an ecological feature to be exploited much as a river might be tapped for irrigation water. The risks involved in the original initiation of a project are now more obvious: risks not merely that it would fail, but that having failed it would survive as a parasite that could not be shaken off or killed.

The issues involved in a decision to terminate a scheme are, of course, not simple. Those responsible for the decisions may not even agree about whether the amount of money already sunk in a project is a relevant consideration. Attitudes and ideas are sufficiently confused and contradictory for irrational elements to have free play. It is extremely difficult, for example, to see the large quantities of fine onions grown on the Perkerra Scheme in Kenya, and to compare the green irrigated fields with the surrounding desert, and at the same time to sustain a conviction that the scheme should be abandoned. Running water through channels and onto dry land, growing abundant crops where there was only bare soil and barren bush before, and enabling people to enjoy a level of prosperity they have never previously known, appear inherently and incontrovertibly good. It is Isaiah's vision:

> The wilderness and the solitary place shall be glad for them; and the desert shall rejoice, and blossom as the rose (The Bible).

To suggest closure seems ignoble and destructive, an affront to the aspirations and achievements of the human spirit. If a neutral visitor can have this feeling, it may be expected all the more in those whose lives and work are bound up in a scheme. Yet the power of this emotion multiplies the risks of starting projects of this sort through making it exceptionally difficult to close them down however uneconomic they may prove.

There is, indeed, a strain of Utopianism in most complex settlement schemes. Often there is an idealized view of the human situation that settlement will create. In colonial times this was often the stabilized African, fixed and controlled on a piece of land. Since independence, it has varied: in West Africa it has been an urban farmer; in Kenya, a sturdy yeoman; in Tanzania, a cooperative worker. Another Utopian aspect is the frequency with which stresses and breakdowns are not anticipated: as Apthorpe (1966, p23) has pointed out, provision is often lacking either for failure of the social system or for mechanical repairs. Again, it is very common for the targets for land preparation, settlement, production and withdrawal to be wildly optimistic and for achievements to fall far short of them. These features are partly explicable in terms of the self-delusion of men who are transported by a vision. When an ideal is pursued by a whole community, as in some communal economy schemes, it may make a scheme feasible through the sacrifices the participants are prepared to accept; but when the vision is only in the mind of the initiator, as it has been with most complex settlement schemes, the effects are often a sequence of unrealistic estimates, uneconomic measures and personal commitments which comprise part of the risks of the project.

Resisting temptation[7]

Since all these disadvantages have applied in the past they can be expected to continue to apply in the future, and should be taken into account in assessing proposals for settlement schemes and similar agricultural projects. It is not enough to carry out evaluations[8] which consider only those economic factors which can be quantified; it is necessary also to include administrative factors and the probable motivations and behaviour of the actors involved. Allowance has to be made, for example, for the expected patterns of settler and managerial behaviour, for departmentalism, for staff discontinuities and for the inbuilt incompatibilities of scheme systems. Moreover, comparisons with alternative approaches to agricultural development should take into account the high opportunity costs of trained staff and the expected ease or difficulty of abandoning a project or programme if it proves uneconomic. When all this is done the case against high capital and complex settlement schemes becomes stronger than when only conventional cost–benefit criteria are used. While this does not mean that such schemes should be ruled out altogether, it does mean that they should be approached with greater care and understanding.

Where a settlement scheme is unavoidable, and where there is a choice of type to be adopted, there is much to be said on organizational grounds for the simplest type of scheme that is compatible with the circumstances of settlement. The simpler approaches are relatively undemanding of scarce administrative and technical capacity, and engage it for shorter periods. They involve relatively low risk and low commitment. Moreover, schemes with individual holdings exploit the drives of property ownership and individual incentive which can make productive the labour which is the most abundant unused resource in much of the third world. The simpler schemes also require intermediate levels of organization corresponding with the intermediate technology which may also be appropriate. If the beginning is ambitious, a complex organization may collapse and find equilibrium at a lower level; but if the beginning is modest, a more complex technology and organization can grow up organically and gradually. For example, the tractors appearing on Chesa in Rhodesia and on the Kenya Million-Acre Schemes as a result of settler initiative represent a self-sustaining upward movement in which productivity may increase without heavy government investment or commitment. If such developments are to be possible, it is important that advisory and technical services be available when needed, and even more important that the system of land tenure adopted should allow for future flexibility in farm size. Given such flexibility, it is usually safer and sounder to develop piecemeal from an existing base, whether this is farmers already on their land or settlers, already on a scheme, than to attempt radical transformation in one long step.

Settlement schemes, particularly those which are complex in system, will remain temptations. Because of their creative possibilities, they will continue to find energetic and enthusiastic sponsors. Because of their visibility, clear boundaries, organizational coherence and Utopian overtones, they will no doubt continue to attract successive colonization – by administrators who negotiate their emergence, constructors who build them, agriculturalists who manage them, settlers who populate them, and in their wake foreign aid personnel and research students[9] in various capacities – all of whom will find satisfaction in occupying a bounded and identifiable territory. What is vital is not that such schemes should be avoided on principle, but that those who act in these situations should appreciate what is happening. It is especially important that those who make development decisions should understand themselves well enough to be able to compensate in their acts of judgement for the strong pull of the psychological attractions of such schemes, and should be able to see clearly the risks they entail and the benefits that might accrue from alternative uses of the resources involved. Exceptional restraint and imagination are needed among politicians and civil servants if the lure of the big scheme is to be neutralized so that a balanced and realistic assessment can be made. Perhaps it is fortunate that so many African politicians and civil servants possess and farm their own land. While this may be a distraction it may also satisfy desires for property and territory, so that they are less prone than their expatriate predecessors to seek such satisfaction through their work. It may in the long term enable them to take more balanced views of policy and to appreciate more fully the alternatives that exist. Certainly it is important to recognize that the choices are neither clearcut nor easy. It is not enough, as was done in Kenya before independence (Government of Kenya, 1962, p1), to quote Gulliver's report of the views of the King of Brobdignag:

> And he gave it for his opinion, that whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together (Swift, 1726, Chapter 7).

For the issues are less simple: they include whether, with the same resources, many more ears of corn, or many more blades of grass, might not be grown in other ways or in other places; and whether those politicians and civil servants who make major policy decisions have the freedom, the insight and the courage to choose those other ways or places, however unspectacular they may be.

Learning from project pathology: The case of Perkerra[10]

Introduction (2004)

The Perkerra Irrigation Scheme in Kenya was launched precipitously in 1952 during the Mau Mau Emergency. It was known that there had been a proposal for irrigation on the Perkerra river, but the 1936 exploratory report could not be found. Detainees were placed in camps on the site and employed on road building and preparing works and fields for irrigation. From the start, capital and recurrent costs were high and revenue negligible. Tenants were settled but many left. Areas irrigated consistently fell far short of those targeted. Agricultural and marketing problems were intractable. In 1959 with just over 100 settler families, it was decided to close the scheme down. The decision was then reversed and changed to running on a care and maintenance basis for three years. By 1962 closure had become more difficult. The scheme was instead expanded to try to make it less of a recurrent burden on government. By 1967, with over 500 settler families, commitment had become even harder to reverse, and the scheme continued, with cross-subsidies from an economically successful sister scheme in another Province, the Mwea Irrigation Settlement.

Lessons from Perkerra (1973)

Many lessons could be culled from the Perkerra experience. Only some of the more obvious and important will be mentioned here.

In the first place, the high costs and risks of hasty development with inadequate surveys are abundantly clear. To embark upon a major irrigation project with little knowledge of river flows and with what limited knowledge there is indicating unreliability; without any assurance that a cash crop can be grown and marketed; without experience of tenants' performance; and without any pilot project – these are to court disaster. Moreover, one effect of such ignorance is to encourage over-investment in unprofitable directions which have then to be abandoned: the 430 acres of basin irrigation which were overrun by nutgrass, and the extensive cultivation, before adequate trials had been carried out, of tomatoes, groundnuts and even onions. When, as has occurred at Perkerra, most of the experimental work is carried out not on a research station but with tenants on their plots the risks of failure are multiplied by the dangers of tenant dissatisfaction, of loss of confidence in the management, of absenteeism and ultimately of permanent departure from the scheme.

Second, when a complex project requiring a favourable coincidence of several interdependent factors begins to run into trouble, difficulties tend to compound one another. On Perkerra, lack of water has sometimes limited the acreage that can be irrigated, in turn limiting returns to tenants and revenue to the scheme, increasing the dependence of the scheme on subsidy and aggravating the problems of tenant management. Unstable onion prices have affected tenant and staff morale as well as revenue. Evictions and other disciplinary measures to secure effective tenant performance may be partly self-defeating by reducing the tenants' sense of security on a scheme and encouraging them to spend more time and energy on their off-scheme activities. Such chain reactions as these make heavy demands both on managerial skill and patience and on the financial resources of a parent organization. Where a scheme has, like Perkerra, a generally unfavourable physical environment and narrow technical limits of tolerance, able management may reduce or cushion some of these reactions but is unlikely always to overcome them. In these circumstances, financial support of various forms becomes the variable that is easiest to manipulate, with the result that a scheme is maintained but at a heavy cost to the rest of the economy.

A third lesson emerges from the process of creeping commitment to the scheme, starting with the first ideas of replacing the indigenous irrigation which had been destroyed (by a flood in 1919), leading to preliminary surveys and then to a situation in which the idea of irrigation was at large and ready to be seized on whenever an opportunity presented itself. There was never any meeting or moment at which a decision to implement the Scheme was clearly taken. Even the siting of the camp at Marigat was only partly associated with the possibility of irrigation. But the very presence and use of the labour; the posting in of staff; the allocation of funds; the physical developments such as building the camp, construction of the weir, and land preparation; the deepening enthusiasms of individual officials and the increasing involvement of departmental interests; the visits of VIPs to inspect progress; the selection, induction and management of tenants; the growing and marketing of crops – all these in multiple ways progressively secured the scheme as a permanent entity and strengthened its capacity to survive. It became increasingly difficult to close it down. To abandon the scheme would have meant to accept failure, to write off heavy government expenditure, and to have to resettle tenants, transfer staff and save a number of faces. It was always easier and involved less immediate acceptance of responsibility to allow the scheme to continue. The chance in 1962 when the tenants could have been resettled in the former European highlands was allowed to slip, and by 1968, with some 500 tenants to varying degrees dependent on the scheme, closure had become politically and humanly difficult even to contemplate.

A fourth observation is that the true costs of a project like Perkerra may usually be greater than their apparent costs. To evaluate any scheme is, of course, a complex operation with several quantifiable and many unquantifiable factors to be taken into account; and, to be sure, even with Perkerra there have been hidden benefits – learning on the part of the tenants, including their introduction to a cash economy; experience gained by government officials; investment of incomes generated by the scheme; indirect government revenue; and seasonal employment, among others. But schemes which are heavily committing in terms of capital expenditure, departmental and individual involvement, and political interest and support tend to receive a perverse protection: the levels of external support and of tolerance in evaluation vary inversely with their economic performance. Except in stringent economic evaluations, 'success' for a scheme like Perkerra is defined in less exacting terms than for an economically more viable scheme such as Mwea. Protective standards of assessment and hidden subsidies are easily combined to give a false impression of favourable economic performance. Moreover, a scheme such as Perkerra has to be evaluated not just in isolation but in terms of benefits forgone from alternative uses of the resources involved – especially capital, managerial competence and effort, and labour. Had the sum of over £500,000 and the human resources invested in Perkerra by 1968 been used in other ways, the results might have been substantial benefits instead of continuing indefinite liabilities.

These four lessons – the costs and risks of haste and ignorance; the compounding of problems in complex projects; the irreversibility of the creep of commitment; and the high true costs of poor projects – combine in a criterion applicable to choices in agricultural development. The Perkerra Irrigation Scheme, with its requirement from the start of complex and continuing organization involving government support, can be contrasted as a policy with the implications of an incident in the history of the scheme. In 1961 the manager noted that 'A tenant was given a sample of Taboran maize seed which ripened about four weeks earlier than the local variety and yielded at a rate of 11 bags per acre. The tenant concerned was besieged by others wanting seed to plant.' This was, of course, an event on an irrigation scheme, but the implications are wider and apply to non-irrigated agriculture. The contrast here is between on the one hand a major project like Perkerra which requires ongoing government involvement, and on the other programmes like the introduction of a new seed variety which can be one-shot efforts. In a major project the risks and liabilities are shouldered by government: if the project succeeds, government is obliged to continue to service and manage it; if it fails, it may prove politically and administratively impossible to abandon it. In the one-shot programme, however, the risks and liabilities are accepted by the individual farmers: if the innovation succeeds, it is propagated without further government intervention; if it fails, it is quickly and easily abandoned by the farmers without additional cost or administration for government.

There are, of course, a great many other considerations which bear on policy choices; but capital and administrative capacity are typically scarce resources to be used sparingly; and in choosing between alternative approaches to agricultural development there is a case, other things being equal, for preferring those which are cheap, simple, administration sparing and easy to withdraw from to those which are expensive, complex, administration intensive and committing.

It is not enough merely to be aware of these considerations; there must also be a climate and machinery in government to make sure that they are taken into account. In British colonial government in East Africa in the 1950s there was a relative absence of economic criteria in official thinking and a readiness to support the initiative of officers at the local level when they promoted projects. There was sympathetic backing in the Kenya central government for the vision and enthusiasm of the civil servants at provincial and district level who energetically launched the Perkerra Irrigation Scheme. Entrepreneurial capacity of the sort which they demonstrated is certainly an asset to a government, but as the Perkerra story shows it can be dangerous unless it is controlled. What is needed is a powerful and perceptive presence in governments which, while not stifling local initiatives, ensures that schemes as unpromising as Perkerra are never begun; for it is far easier to prevent a bad project than, once it has been started, to close it down.

Part 2: Developments, Concepts and Discourse (2004)

The legacy of Perkerra and its need for subsidies has continued into the 21st century. After the 1960s, agricultural settlement projects became less favoured in most parts of the world. Big dams and other projects were increasingly recognized to have high human costs in the many who were displaced, dispossessed and inadequately compensated. Champions within the World Bank and internationally networking activists made lenders, donors and, to a lesser degree, governments, more aware of human costs and more reluctant to fund dams and other projects which displaced people.

Commitment to projects and continuity of aid agency and developing country government staff, created conditions for innovation, learning and changes in practices and policies. In the 1990s, as aid agencies and governments shifted their priorities to *programmes and policy, there were human and ethical costs as projects were abandoned. With the new priority to influence policy so continuity, partnerships, relationships, understanding and trust became and remain more important than ever.*

Irreversibility is neglected in conventional economics compared to risk and uncertainty. The precautionary principle in environmental and other decision making recognizes irreversibility, but it remains underdeveloped as a practical concept. Far more attention should be paid to human activities like quarrying and mining, which are controllable but have effects that are irreversible.

Commitment, continuity and irreversibility are Cinderella words and concepts, which merit more analysis and prominence in development discourse and practice.

Agricultural settlement in decline: Twists in the tale

After the 1960s, agricultural settlement schemes became less common and less conspicuous. In Africa, their problems and costs, the less land available and political factors combined to reduce their popularity and prevalence. In Zimbabwe, although earlier settlements had been quite successful, the greed and intransigence of the later political leadership prevented an orderly programme that might have served equity and peace by transferring land from European to African farmers, as had been achieved during the 1960s in Kenya. More generally, the withdrawal of the state from administered development such as settlement schemes has been so widespread and so comprehensive that we find ourselves now, in the 21st century, looking back on the 1960s as another world.

Legacies of earlier irreversibility have, though, lingered on, with twists in their tails and tales. The Perkerra Irrigation Scheme has survived. For a long time it was probably still a costly recurrent liability.[11] Reportedly its performance improved somewhat in the 1990s with diversification of crops, and contracts from the Kenya Seed Company for growing hybrid maize seed. A research station was established at Perkerra, jointly under Horticulture Research International and the Kenya Agricultural Research Institute. The irrigated area remained low. Papaya and maize were grown on 350 hectares out of the 2350 hectares designated for irrigation. Perkerra was reported to perform relatively well compared with other irrigation schemes such as Hola, West Kano and Bunyala, which were 'virtually dead' (Akumu, 2002). But the vulnerability and financial dependence of the scheme continued.[12] In December 2002, floods in the Perkerra River destroyed the weir and 259 houses. 'The embankment of the water reservoir which used to flow through the canal to the scheme, and which was built way back in 1954, collapsed under pressure from the waters' (Njeru, 2003). So the history of vulnerability to flash river flows, which in 1919 broke the sill of rock on which the Njemps built their brushwood weir for irrigation, was repeated in 2002. For reconstruction the NIB (National Irrigation Board) was to put in US$20,000[13] and the United Nations Development Fund Kenya, US$100,000.[14] It remains to reflect on the relative ease and low cost of closure in 1959 and for a few following years when there was the option of resettlement in the (as they were) 'White Highlands', and then on the continuing costs of rehabilitating and maintaining the scheme. For each generation of government officers, and for local politicians, the easier course was always to keep it going. Moreover, commitment can hardly have been diminished by the scheme's location in the constituency of Daniel arap Moi, the long-time powerful President of Kenya. The opportunity cost of the funds devoted annually to maintaining the project must have been high, indeed.

The history of the rice-growing Mwea Irrigation Settlement is a contrast. From its inception, it was economically more viable. But, increasingly, during the 1990s farmers' incomes were hit by dues deducted by the management, heavy charges for milling and marketing, and competition from cheap rice imports with liberalization. The centralized administration, seen in earlier days as a strength of the Mwea scheme (Giglioli, 1973; Veen, 1973), gave scope for much resented corruption. Cross-subsidization also took place from Mwea to Perkerra and other schemes. In 1998, farmers rebelled and took over the management, milling and marketing. The next year two young men were shot dead in a confrontation with police (Kenya Human Rights Commission, 2000). In 2003, negotiations were in progress to establish a new relationship between the Mwea settlers and the NIB. Interestingly, the very continuity of the draconian rules and centralized organization of the scheme can be seen as a factor leading to the Mwea rebellion, and its end, for a time, as an administered scheme. The lack of democracy, accountability and transparency, earlier thought to be a strength, had become a liability.

Worldwide, administered agricultural settlement schemes became rare during the 1980s and 1990s. There were fewer resources, less land and the state was in retreat. In India, large- and medium-scale irrigation did not settle farmers, but supplied water to farmers on the land that they already farmed. In Israel, the idealistic and communal organization of the *kibbutzim* eventually came to an end. Elsewhere, the state disengaged where it could from responsibilities to settlers.

Some exceptions to these trends do, though, stand out, ranging from the tightly administered to the near chaotic. For example, on Palestinian land, the closely protected, notoriously illegal Israeli settlements were precisely intended to be irreversible forms of appropriation and colonization, excluding Palestinians from their land. In Sri Lanka, in a humane but closely administered tradition, the Mahaweli Development Authority continued to settle families on newly irrigated land and to provide a high level of special services. In southern Africa, there were limited programmes of buying out large European farmers and settling African smallholders. In Ethiopia, despite the bad record of earlier population transfer and resettlement, the early 2000s saw renewed attempts to resettle people from the highlands to the lowlands. At the chaotic extreme, in Zimbabwe, self-settlement of self-designated freedom fighters took place on commercial farms from 2001 onwards, carried out by force and with disastrous economic consequences.[15] In their different extreme ways, the Israeli and Zimbabwean governments pursued or permitted settlement with gross disrespect for human rights and legality.

As for refugees, in 2003 there were, in the world, some 20 million persons identified by the UNHCR (United Nations High Commissioner for Refugees) as 'people of concern' (UNHCR, 2003). Of these, 12 million were refugees. The remainder included internally displaced persons, stateless persons, asylum seekers and returnees. Refugees were concentrated especially in Africa, Thailand, Iran and Pakistan. Earlier, during the 1970s and 1980s, hundreds of thousands of refugees had been established on agricultural settlements, notably in Tanzania at Mpanda and Ulyankulu. But during the early 21st century, almost all refugees were either dispersed among host populations or held and supported in camps. New agricultural small farming settlement projects for refugees and displaced people followed the global trend and had become rare.

'Oustees', rights and ease of exit

The retreat from agricultural settlement during the 1970s and 1980s was paralleled by neglect by governments of responsibilities for people displaced by dams, roads and other infrastructure projects. In 1994 and subsequently, those displaced were estimated to number worldwide about 10 million a year (World Bank, 1994; Mehta, 2002). With dams, the word 'oustee' came to be used. Earlier, during the 1960s, Nuba and others who lost homes and livelihoods to Lake Nasser, created by the Aswan Dam in Sudan, were given the option of resettlement on the new irrigation project of Khasm-el-Girba; and some 80,000-odd people displaced by the Volta Dam in Ghana were offered resettlement in new communities, which a majority of them took up (Chambers, 1970). But no such responsibilities were similarly discharged in India on any scale, despite the building of many dams and the displacement of hundreds of thousands of marginal and politically impotent poor people. Over four decades in India, 20 million people were displaced by development programmes and forced into involuntary resettlement. Seventy-five per cent of them were without 'rehabilitation', and the vast majority were impoverished by the process (Cernea, 1997). Michael Cernea and his colleagues at the World Bank, and Thayer Scudder and others outside it, showed how damaging displacement was to lives and livelihoods, how widely ignored were the rights and interests of those displaced and how much more numerous they often were than was acknowledged in project documents. As a vigorous and committed group, they were instrumental in drawing up and gaining agreement for the World Bank's policy on involuntary resettlement, issued in 1980. This major step forward was influential both inside and outside lending and donor agencies, though less so with governments. At the same time, internationally networking activists made lenders, donors and, to a lesser degree, governments, more aware of the human costs of dams and other projects that displaced people and more cautious about funding them (Brown and Fox, 2001). Evaluation and research have improved understanding of involuntary resettlement and of what could and should be done (e.g. Cernea 1997, 1999; Picciotto et al, 2001). The World Bank code, international networking and lobbying by civil society, the new human rights agenda, and predictable protests and adverse publicity have increasingly combined to discourage lenders and donors from supporting big projects that displace many people.

The Sardar Sarovar Dam in India, and the Narmada River project of which it was a part, is a case in point. It developed into a high-profile saga with dramatic civil disobedience. The Indian Central and State Governments failed to meet World Bank requirements for compensation and resettlement of the people who were to be displaced. When a distinguished international panel laid bare misinformation and abuse (Morse and Berger, 1992), the World Bank withdrew its support. The Indian Government pressed ahead on its own, facing a long and high-profile campaign of protest led by Medha Patkar and supported by the novelist and activist Arundhati Roy (Roy, 2002).

Other withdrawals of international aid followed for other dams. The UK government backed off from supporting the Pergau Dam in Malaysia when the World Development Movement brought a case against it and a UK court ruled that it was illegal. In 2001, in the face of strong criticism, it also withdrew support from the Ilisu Dam in Turkey, which would have displaced a large Kurdish population and inundated historical sites. Meanwhile, the World Commission on Dams (WCD, 2000; Imhof et al, 2002) set new standards for inclusiveness and consultation, having among its members both Medha Patkar, who as an activist had been on hunger strikes in protest against the Narmada project, and Goran Lindahl, the chief executive of one of the world's largest engineering firms (Dubash et al, 2001, p1). The WCD's remarkable consensus report presents a new policy framework that gives prominence to the rights of people adversely affected by dams (WCD, 2000, p240ff).

In this new climate, international funders, though less so governments (as India's Narmada and China's Three Gorges projects illustrate) have become more circumspect in keeping open options for exit from such projects. With the earlier settlement schemes in Africa, irreversibility of commitment was linked to political and moral responsibility to those who had been settled. After a phase of neglect, such obligations are now again more extensively recognized and accepted. Commitments have become more public and open to scrutiny, more frequently debated and less firm. High-profile opposition has made it easier for funders to withdraw support. The irreversibility found in earlier projects is now less common because of greater awareness of the consequences of displacement and the opposition that new projects provoke.

Commitment, continuity and creativity

Changes in commitment can be understood in the context of the well-recognized changes in development policies and practices of both national governments and aid agencies.

To summarize these in broad brush terms, during the 1950s and 1960s, infrastructure projects were prominent – for example, industrial plants, harbours, roads, railways, telecommunications, airports and irrigation projects. The 1970s became a heyday for area-based initiatives, including Integrated Rural Development Projects promoted and supported by the World Bank (World Bank, 1988). These did not have settlers, only small farmers or pastoralists already on the land; so when many failed, as they did especially in Africa, they were easier to abandon. Unlike Perkerra, they passed into history on the ground, leaving a legacy of disillusion, debts and staff housing. In aid policies during the 1980s and 1990s, structural adjustment programmes became prominent, required by lenders for the repayment of debts. And the 1990s were marked by shifts towards sector programmes and direct budget support, debt relief, good governance, participation and human rights policies proclaimed as pro-poor. As the new century came in, lenders and donors were abandoning field projects and focusing on policy.

Some big projects, though, if well surveyed, fairly administered and then irreversibly implemented, are needed and justified. I was probably wrong, on an International Labour Organization mission to Sri Lanka in 1978, to muster arguments against the Accelerated Mahaweli Development Project to increase hydropower and irrigation and to brand it Sri Lanka's *Concorde*.[16] And who now would wish to argue that it would have been better not to have built the Volta Dam or the Aswan Dam? Some big projects are right. Some are not. And much depends upon how well and fairly they are undertaken.

All of this may be quite well accepted. Perhaps less explored is the changing significance of dimensions of commitment and continuity and their implications for practice. In what follows, much of the focus is on aid agencies, and their priorities, activities and relations with governments; but much also applies to governments themselves. Let us follow the historical sequence and start with projects.

Commitment and continuity with projects

For exploring the relevance of irreversibility and commitment, especially with projects, insights come from Albert Hirschman's classic *Development Projects Observed* (Hirschman, 1967). From a study of 11 World Bank-supported projects, all of which had serious problems, Hirschman put forward his hypothesis of the 'Hiding Hand'. This was the principle that those proposing and planning projects habitually underestimate the difficulties that will be encountered, but that this may be just as well, since they also habitually underestimate the creativity that can be mustered to overcome them. With hindsight, the Perkerra experience suggests that Hirschman may himself have made an underestimate – of the costs of 'creativity', for these can include recurrent costs of staff, subsidies and protection, additional infrastructure and the pre-emption of scarce administrative capacity. Still, in Hirschman's view, too little commitment and too easy withdrawal could mean premature abandonment before there was time to learn and improve. This, he argued, was a weakness of agricultural projects, which were easier to abandon than, say, electric power or railways. Irreversibility, in his view, could be an asset because of the creativity it stimulated and the learning to which it gave rise.

Hirschman's thesis about commitment, continuity, learning and creativity is borne out by the RIPS (Rural Integrated Project Support) Programme in Lindi and Mtwara Regions in Tanzania (Freling, 1998; Groves, 2004). Finland supported a programme there for some 20 years, much of it installing water supplies. By all accounts, these were a substantial failure. Accepting failure and abandoning the project would have been easy to justify. But the Tanzanian Government and the Finns did not give up. They hung in and tried again. There was then a continuity of involvement and commitment of key individuals on both the Finnish and the Tanzanian sides, which fostered a good spirit of long-term trust, understanding and partnership.[17] In 1993, an Indian trainer, Kamal Kar, introduced participatory rural appraisal (PRA) through a series of workshops (Johansson, 2000). Participatory approaches gained strong support from the two regional commissioners, Colonel Nsa Kaisi and Colonel Anatoli Tarimo (and, subsequently, his successor A. Y. Mgumia). Implications for institutionalization and bureaucratic change were recognized (Kar et al, 1998; Swantz, 1998). The programme was transformed. Innovations multiplied (Freling, 1998). To take but one example, participatory media were developed (de Waal, 2000) through a village radio network and through participatory video. These enabled people to make claims and supported mediation between competing or conflicting stakeholders. Participatory video was used in reforming a fish market, forcing officials to use the correct procedures and leading to the person who was 'eating' the tax collected being transferred elsewhere (Nyamachumbe, 2000). It also played a key part in the turbulent process of ending the dynamiting of coral to catch fish (Swantz et al, 2001). Another innovation was to introduce PRA with participatory planning and action in most of the communities in the two regions. The results of this community-level participation were so successful that, through a sequence of national workshops, it influenced Tanzania-wide policy. Results included a permanent secretaries' two-day retreat on participation (MRALG, 1999) and a later one for regional administrative secretaries. Throughout the 1990s, the donor agency and the Tanzania government were co-learners and co-beneficiaries. Had they given up after the earlier 20 years of failure, the positive lessons from pioneering participation would never have been learnt and national policies and practices would not have been influenced.

The Sida-supported Mountain Rural Development Programme in Vietnam is another striking illustration. Sida had a long-standing relationship with Vietnam as the only Western donor who hung in with support through the 1960s and 1970s. A sequence of projects, initially a pulp mill, then for forestry and farm forestry, and subsequently rural development, involved long continuities of staff and relationships. Edwin Shanks and Bui Dinh Toai noted in a paper they wrote for a conference in 2000 that their combined experience was 16 years, having worked on the project since 1993 and 1991, respectively. They also observed that 'due to the relative stability of staffing structures in Viet Nam, many of our colleagues still working on the programme at province and district levels were also involved from the very beginning' (Shanks and Toai, 2000, p23). It is difficult to imagine that the slow, patient and successful introduction and co-evolution of participatory approaches to government agencies in that project could possibly have been achieved without this continuity and sustained commitment.

With aid agencies shifting to sector support and policy influence, development projects were being abandoned during the early 2000s. In Uganda, between one financial year and the next, DFID's (the UK Department for International Development's) ratio of project-to-programme funds shifted with astonishing abruptness from 5:2 to 2:5, without a significant change in total.[18] Ironically, this was at a time when, in my view, lenders, donors and governments were getting better at learning from projects. But as and when these were terminated, governments and aid agencies lost the precious opportunities they had had for innovation and co-learning. With one project in Tanzania, local-level staff had devoted years to project preparation and negotiation only to find that they had been led up the garden path and there would be no project (Groves, 2004). With another in Brazil, after relationships with NGOs (non-governmental organizations) and communities had been built up over three years, people's time and energy had been invested, and enthusiasm and expectations had been raised, a decision was taken in DFID to withdraw, leading to much anger, anguish and disillusionment. The hidden costs of such abandonment can be incalculable. Local people who have engaged in participatory planning and have been led to expect support are left in the lurch and reconfirmed in their resentment and cynicism about government. Field staff are seen to have misled their clients; they are made to look foolish, if not duplicitous, and are furious, embittered and demotivated. Decent and perceptive aid agency staff, too, are demoralized, embarrassed and ashamed, but do not have to face the people on the ground. Centrally isolated office-bound policy makers in northern capital cities may be blithely or wilfully[19] unaware of the distant damage they have done. All too often, abandoning projects was unethical and anti-poor.

With experience from western India comes David Mosse's (2003, 2005) fascinating, perceptive and subtle analysis of the IBRFP (Indo-British Rain-fed Farming Project) with which he was closely involved until 1998, and which he revisited and reviewed three years later in 2001. Despite his early criticisms, and despite managerially exacting contradictions in the project, he shows that much had been achieved, not least through participatory seed breeding and selection. This was a core project innovation that challenged the prevailing regulatory frameworks and bureaucratic practice of Indian agricultural research (Witcombe et al, 1996), with huge implications for policy and practice. The project had also 'brought a version of "development" more meaningful than any previous to Bhil tribal communities excluded from even the most basic state services' (ibid, p24). However, by 2001 it had fallen from favour in DFID and was threatened with closure, not because it was failing but because projects had become unfashionable. As Mosse (2003) puts it:

> Project practice seemed to me unchanged – meaningful engagements between staff and villagers still produced important local benefits even under conditions of severe drought. But a fundamental change *had* occurred, not in the project but in donor policy … DFID's India programme had become reorganized around the funding of state-wide government programmes, sectoral reform and donor–government partnerships. Unable

> to articulate this policy, the IBRFP project began to lose its support and, consequently, its reality. It bore new policy labels of exclusion: 'enclave project', 'niche project', 'replicable model', 'parallel [to the state] structure', 'sectoral, downstream, micro-managed project'. IBRFP had suddenly become the flared trousers[20] of the DFID wardrobe.

In abandoning projects, lenders and donors have succumbed to a tragic pathology. Notwithstanding the common view of colonialism, I found, in the late colonial settlement projects that I studied in Africa, a strong commitment of local-level administrators to 'their' projects and to the settlers. Administrators on the ground were face to face with the realities. To varying degrees, subsequent political representation also provided commitment and support to local projects. It is only now, with lenders, donors and policy makers interacting and influencing one another more and more, insulated in their capital city cocoons, that projects can more easily be abandoned. RIPS in Tanzania, the project in Brazil, and IBRFP in India all provoke sad reflection on the costs of abandoning projects: staff demoralized, people disillusioned, government discredited, 'money down the drain', benefits to the poor forgone, and opportunities lost for ground-truthing, learning, innovation and capacity-building. In our brave new 21st century of aid, for many poor people, projects have not proved irreversible enough.

Commitment and continuity with policy

This view gains new relevance with the dominant development aid policies of the new century. There are signs of a new consistency in two domains: in rhetoric, extolling partnership, country ownership and policies that are pro-poor; and in targets, with the international and now MDGs (Millennium Development Goals) set for achievement by 2015. Sector programmes may, perhaps, not demand as much long-term commitment as projects. But whether for projects or for sector support, inconstancy is a feature of much aid. In this, agencies differ. United States Agency for International Development (USAID), for example, stands out for its short-term swings of policy and vocabulary, and its relative unreliability.[21] Overall, the shift from projects to sector programmes and policy influence may have meant a move for aid agencies from the grounded, bounded and stable to the more nebulous, permeable and inconstant.

With projects, failures were harder to hide. There were reasons to hang in there and try to make them work. With sector support, failures by lenders, donors and governments may, perhaps, tend to be less embarrassingly conspicuous and responsibility less attributable. More actors are involved. The scale is wider. The impacts are further away. So responsibility and accountability are more diffuse. Both political risk and institutional commitment have diminished. In consequence, it may be easier to exit and to deny responsibility. The new dangers implied may not be well recognized by lenders, donors and recipients. The dangers include, as Albert Hirschman might note were he to revisit the aid scene, that less long-term commitment and less continuity mean less creativity and less learning.

Personal continuity, motivation and effectiveness

With the shift of emphasis in aid from projects to sector programmes and policy influence, and with the language of partnership and ownership, so relationships and continuity have become ever more important (Eyben, 2004; Groves and Hinton, 2004). Good relationships are fostered by continuity of aid agency staff in country and in post. Continuity also provides incentives and opportunities for vital learning. How can a foreigner be engaged in sensible policy dialogue without knowing and understanding a country?

A crucial aspect of continuity is people staying in the same post, place or sector, gaining experience and developing good working relationships. Quite exceptionally for an Indian Administrative Service officer, Syed Hashim Ali was left in charge of irrigation command area development in Andhra Pradesh for seven years, from 1974 to 1981. Through this continuity and his personal commitment, much learning took place and he was able to make and oversee major shifts and improvements in policy and practice. Continuity in linking field experience with policy can also be important. E. G. Giglioli's experience as manager of the Mwea Irrigation Settlement was crucial to the insights and authority that he later brought to the establishment and management of the NIB in Kenya (Chambers and Moris, 1973).

Partnerships in the Philippines and in Uganda show how continuity and long-standing relationships can be the foundation for major changes. Over some ten years in the Philippines, Benjamin Bagadion of the National Irrigation Administration and Frances Korten of the Ford Foundation worked together with a stable network of colleagues. During this time they were instrumental in gradually transforming much irrigation policy and practice (Bagadion and Korten, 1989). In Uganda, the UPPAP (Uganda Participatory Poverty Assessment Process) was promoted and supported by an alliance of champions in both donor and recipient organizations working closely together over a number of years (Yates and Okello, 2002, pp90, 93; Kakande, 2004). It continues as an innovative programme that has given poor people's priorities policy clout and has also influenced PPAs (participatory poverty assessments) in other countries. In my judgement, neither the Philippine irrigation reforms nor UPPAP could have occurred without the relationships, trust and shared purpose, which could evolve because the main actors remained for some years in their posts and organizations. Without that continuity, the loss would have been not just national, to the Philippines or to Uganda: irrigation management in the Philippines has probably been more influential worldwide than in any other country, and UPPAP experience has influenced many other PPAs. The loss would have been international, to many countries and to our understanding of how to do better in development.

Expected and actual continuity in post has profound effects on motivation, behaviour and learning, whether in government, INGOs (international non-governmental organizations) or aid organizations. Over time relationships can go beyond mutual respect and collegiality and flower into friendship.[22] Three conditions that help are long journeys together by car or train, mild hardships in the field and a shared vision. Continuity in post and relationships rise in some places and decline in others. In INGOs, in some countries, there is an impression that staff are switching organizations with greater frequency, treating them as stepping stones more than as places in which to stay and work for a matter of years. But those who do hang in gain types of experience denied to those who hop about. World Neighbours, one of the most innovative INGOs, has staff members with over 20 years' service. In recruiting it looks for people whose careers have shown 'stick-to-itiveness' – that is, who have stuck to the same job or organization for a substantial time (Jethro Pettit, pers. comm.).

The behaviour of those who expect short spells is predictable. If foreigners, they lack incentives to learn a local language or to take pains to understand local people and conditions, or to take a long view. If energetic and committed, they are liable to be tempted to go for actions with quick effects, neglecting those that need longer-term negotiation and support. For aid agency staff, 'It is difficult to learn and to assume a long-term vision in a local donor community. Each individual is operating in a short time frame related to average residence of three years in any country and she wants to see herself as having "made a difference"' (Eyben, 2003, p28). In their haste, staff make mistakes from avoidable ignorance. Not having to stay long enough to deal with intractable problems, they do not have to muster Albert Hirschman's creativity in overcoming them. Moving on soon, they are not there when the chicken comes home to roost. There is little incentive to develop more than superficial relationships, and as Rosalind Eyben has argued and shown, relationships matter for supporting change in favour of poor people (Eyben, 2004).

Opportunities to learn and change are missed. These are among the costs of staff moves in the restructurings endemic, if not epidemic, in some aid agencies. Uncertainty and transfers impede other changes. In ActionAid in the UK, the introduction of the new radical ALPS (Accountability, Learning and Planning System) became increasingly difficult when 'staff were coming and going at all levels' as part of a massive restructuring process (David and Mancini, 2004, pp17–18). Individual and organizational learning are hampered. Lack of continuity means that by the time lessons can be learnt from what works and what does not, and how mistakes can be mitigated, staff have moved on. After reviewing the history of a donor-supported development programme in Kenya, Samuel Musyoki (2003, p166) concluded: 'The staff turnover in bilateral programmes is very high and there is a tendency of the new management to erase history and create a new knowledge base.' Just as the benefits of continuity are habitually underestimated, so too are the costs of premature transfers. A successful incumbent in almost any responsible post, whether in a government, national NGO or aid agency, tends to achieve more in a third year than in the first two together, and again more in a fourth year than a third, by which time much has been learnt, and relationships and understandings have had time to mature. Diminishing returns set in, if at all, after five or six years or more.

The importance of continuity is also indicated in the reactions of developing country nationals, whether in governments or NGOs, to foreign staff, and whether this is at local or central levels. They resent the short time that those in aid agencies spend in one place. No sooner have they got to know and developed a working relationship with one person than they leave, another takes over and they have to start all over again. Relationships are fractured and understandings are undermined. In the words (October 2003) of a developing country national about USAID 'When we negotiated there was a very good person. Then the boss changed and was very bureaucratic and she left.' Such discontinuities occur with nationals working in INGOs as well as with foreigners. ActionAid's community development workers in The Gambia 'have, on average, been moved every one or two years, with the attendant need to familiarize themselves with a new area, to build trust and sometimes even to learn a new language before they could start to perform to a reasonable standard' (Howes, 2002, p114). When some ActionAid staff in India were concerned that their local NGO partners would resent their relatively high salaries, they were surprised that there was no objection as long as they stayed in the same place for a decent length of time. Then they could get to know one another and develop mutual understanding. Salaries were unimportant compared with continuity and longer-term relationships (Amar Jyoti, pers. comm.).

In sum, the costs of lack of staff continuity are unseen, unaccounted for, incalculable and often unnecessary. At the same time, continuity is not a simple thing, always to be maximized. From the point of view of a foreign agency, a danger is perceived of out-posted staff 'going native', becoming personally, professionally and emotionally too close and too attached to a country and people. When staff fail it can be right to transfer them. When they move they learn new things. But with the focus of aid on policy, it matters more than ever for aid agency staff to understand local conditions.[23] The costs of lack of continuity, always high, have risen further. Only three years in a post looks too low. The proximate costs of early transfers are relationships broken, trust undermined, demotivation and learning forgone. The wider effects are bad for poor people through errors of judgement and what is then done and not done.

Responsible commitment and continuity can, then, be seen to matter now more than ever. They are a moral imperative where poor people have been led to invest their time and energy in expectation of support. They are a practical condition for constructive relationships, trust and learning. Understanding and optimizing commitment, continuity and their synergies should be high on the agenda for development in the 21st century.

Irreversibility

When a word lodges in the mind, it surfaces in different contexts. So it has been for me with 'irreversibility' since writing my thesis.[24] What began with seeing how commitment to settlement schemes could be irreversible, as with Perkerra, led to thinking of and seeing irreversibility in other domains, including economic decision making and environmental change.

To sharpen the issues, consider extreme and tragic forms of irreversibility. Perhaps the best known is the extinction of species. A world without the tiger, white rhinoceros or panda would be profoundly diminished. Nor is this a question of only such iconic species, but of a great range that are endangered. The irreversibility and uncertain risks of GM (genetically modified) crops are another case. Less recognized is the destruction of rocks. A stark tragedy is the destruction through quarrying of rocks near Delhi and in and near Hyderabad.[25] These were formed billions of years ago and have weathered over geological time. Apart from intrinsic worth, they have (or had before being destroyed) cultural, aesthetic, ecological, recreational and spiritual value to us humans, giving experiences of place and beauty, sustaining a diversity of life, and providing for the recreation and fulfilment of rock-climbing. Their destruction is utterly irrevocable. Trees that are cut can be replanted. Even soil that erodes can be replaced. But with rocks, restoration is not an option. Once blasted and removed, they are gone. Forever. With a dreadful finality.

Reflecting on these biological and physical examples, if we are to assure options and resources for future generations, irreversibility simply has to be a key concept embedded in our thinking and informing our decisions and actions and non-actions. It is then striking that it is not significant in mainstream economic thinking. Much attention is paid to *risk* – 'the probability or probability distribution of an event or the product of the magnitude of an event and the probability of its occurrence' (Alcamo et al, 2003, p214) and *uncertainty*, the condition of not being known or predictable, where the probability distribution is not known (Devereux, 2001, p508), and each has a considerable literature. But *irreversibility* is less well developed and less frequently mentioned as a concept. Two standard economics textbooks – *Economics* (Begg et al, 2003) and *Economic Development* (Todaro and Smith, 2003) – include risk in their glossaries; but neither mentions irreversibility.

Not only is irreversibility little considered, but conventional economic practice systematically undervalues it. First, discounting gives low or negligible present values to distant future benefits or costs (Chambers and Conway, 1992, pp18–19). Present value has, however, often been taken as a basis for decisions. To correct this, Zhao and Zilberman (1999) have proposed a new concept of irreversibility cost, and point out that discounting may encourage a pattern of developing now and restoring later. This applies, for example, with the high costs of decommissioning nuclear power stations, which in present value terms were very low at the time of deciding to build them. Irreversibility traps a project or society into having to pay such costs.

Second, substitutability is invoked, with the idea that technological development will find substitutes for resources or services that are depleted, damaged or destroyed. In this view, depletion and degradation of ecological capital are not irreversible in the sense that they can largely be overcome by the accumulation of knowledge and of manufactured and human capital.[26] However, even if technological substitutes exist or are found, their cost is typically high, limiting access to those who are more affluent and putting them beyond the reach of communities and people who are less well off.

Third, non-renewable natural capital resources, like rocks, minerals, oil or gas, are not normally given intrinsic value in economic assessments. When they are irreversibly exploited they appear in themselves costless. To be sure, there are the costs of land, licences and royalties, and of extraction, processing and bringing into use; and sometimes costs are attributed to loss of amenity and physical and ecological damage. But non-renewable natural resources are not given an inherent capital value. So they come out on the wrong side of the ledger as benefits when, unless recycled, they are more strictly costs in the form of irreversible losses.

Fourth, the cultural, aesthetic, ecological, recreational and spiritual values threatened or diminished by irreversible 'development' cannot be measured in money; yet they are deep elements in the quality of human life and experience. Attempts to measure some of them in cash equivalents appear crude. What is the dollar value of being able to watch a bird or climb a rock, now and for future generations? Some may justify giving these a cash value as a short-term expedient in order to talk to hard-core economists in their own terms. In my view, responsible imagination and reflection on stewardship of the heritage of countless future generations will always be better and should carry more weight.

The effects of these biases and neglect are pervasive. Take even the report of the World Commission on Dams (WCD, 2000). Though a remarkable achievement and *tour de force*, it does not give irreversibility as much prominence as the concept would seem to merit. For irreversibility applies both to structures and their impacts and to decision processes. Despite siltation, earthquakes and other hazards, dam structures and their immediate impacts are large and irreversible. As for decision making, the central values that run through the report are equity, efficiency, participatory decision making, sustainability and accountability. Irreversibility is mainly addressed indirectly, by presenting five key decision points in planning and project development. Although the last of its seven criticisms of cost–benefit analysis is ignoring 'the effect of uncertainty and irreversibility of investment', the report does not make irreversibility a central issue (WCD, 2000, ppxxiii, 181, 263).

Over the past decade, and offsetting such biases and neglect, some economists have given more attention to irreversibility and related concepts. Faucheux and Froger (1995), for example, examine decision making in the conditions of uncertainty, irreversibility and complexity, which they say characterize most environmental problems. Zhao and Zilberman (1999) distinguish between technical irreversibility, when technologies to mitigate negative impacts do not exist, and economic irreversibility, when 'it is not optimal to restore the development even though technologies exist to do so' (ibid, p560). This is because of the level of what they call irreversibility costs or restoration costs. Faucheux and Hue (2001) in their article 'From irreversibility to participation: Towards a participatory foresight for the governance of collective environmental risks' move the discussion into the social realm, stressing the need for vigilance and describing experiments with forms of participatory 'social foresights' – which articulate 'demand' as signalled in the views of citizens. These include public inquiries, citizens' panels, citizens' juries, consensus meetings and mediation.

Issues around irreversibility became clearer in 2002 in discussions about concepts for the MA (Millennium Ecosystem Assessment). The MA is an ambitious project to understand better the relationships between ecosystems, ecosystem services and human well-being. Members of the multidisciplinary group of 51 authors met four times to evolve the conceptual framework[27] published as *Ecosystems and Human Well-being: A framework for assessment* (Alcamo et al, 2003). This defines concepts relevant to this discussion (ibid, pp208–216). *Irreversibility* is 'the quality of being impossible or difficult to restore, or return to, a former condition'. Reversibility is related to *resilience* – 'the capacity of a system to tolerate impacts of drivers without irreversible change in its outputs or structure'. *Thresholds* are 'a point or level at which new properties emerge in an ecological, economic or other system, invalidating predictions based on mathematical relationships that apply at lower levels… Thresholds at which irreversible changes occur are especially of concern to decision makers.'

In the MA's conceptual framework, values are seen to bear heavily on decision making where thresholds and irreversibility are or may be involved. In the process of evolving the framework, values were much debated, both as *intrinsic* – the value of someone or something in and for itself, irrespective of its utility for someone else, and as *ecosystem services* to human well-being, classified as provisioning, regulation and cultural. Cultural values were recognized as spiritual and religious, recreation and ecotourism, aesthetic, inspirational, education, sense of place and cultural heritage (Alcamo et al, 2003, p5).

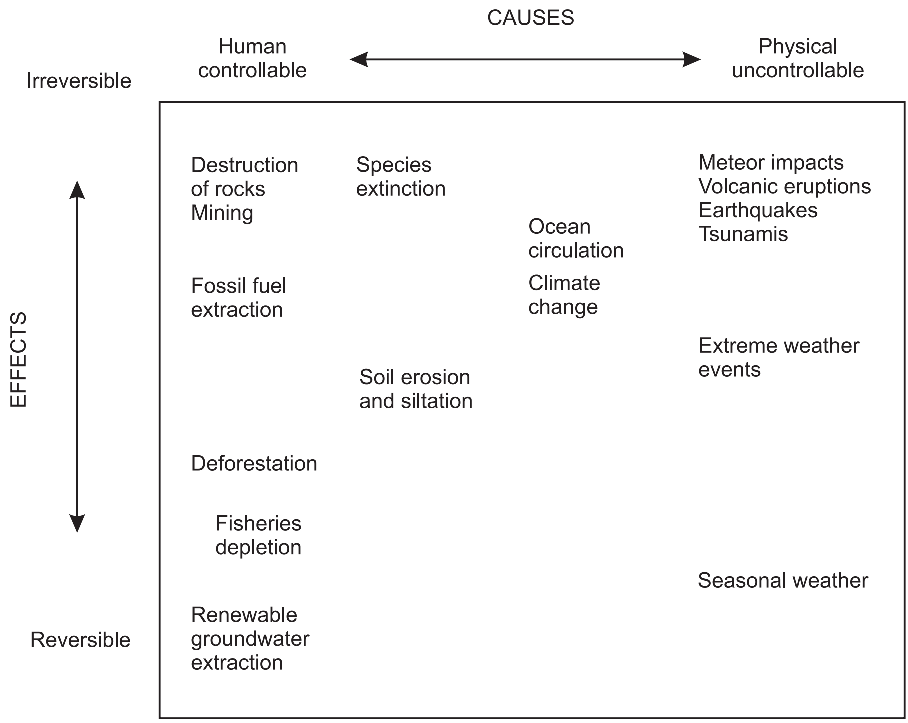
A recurrent theme was keeping options open for future generations. For this, *option value* was defined as:

> … the value of preserving the option to use services in the future either by oneself (option value) or by others or heirs (bequest value). Quasi-option value represents the value of avoiding irreversible decisions until new information reveals whether certain ecosystem services have values society is not currently aware of (Alcamo et al, p213)

The precautionary principle, embodied as Article 15 of the *Rio Declaration* (United Nations, 1992, p3; see also Harremoës et al, 2002) applies here. This is the management concept stating that in cases:

> … where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Despite all of this, and the way it underlies much of the precautionary principle, irreversibility remains an underdeveloped concept.[28] Further steps are needed to distinguish types, degrees and sequences of reversibility and irreversibility. One approach is to classify changes as clusters according to two dimensions: causes,



Source: Developed in discussions with Christopher Chambers and Jenny Chambers

Figure 6.1 *Clusters of environmental change by types of cause and irreversibility*

polarized between primarily human and totally physical; and adverse effects, polarized between reversible and irreversible (as in Figure 6.1). In the north-east of the figure are irreversible large-scale events beyond our control, most of the effects of which are irreversible – earthquakes, meteor impacts and volcanic eruptions. In the east are tsunamis and extreme weather events such as tornadoes, hurricanes, floods and droughts that are uncontrollable, but where there is more scope for mitigating adverse effects. In the south-east is seasonal weather, uncontrollable but often with reversible adverse effects. In the south-west is renewable groundwater extraction, and above it deforestation and fisheries depletion, which are less reversible, at least in the shorter term.[29] While these are all vitally important, and so often demand urgent and sustained intervention, it is the remaining areas that merit the closest and most intense attention: the north-west with mining, oil and gas extraction, quarrying and species extinction – controllable but irreversible; and the north and centre with climate and ocean circulation change, and soil erosion and siltation. These are areas where human agency is a major cause and adverse effects are irreversible in the medium and long term or forever. It is in these areas that long-term future options are closed off through human action, and that the precautionary principle applies, and should be made to apply, with most force.

To take the rocks example, the short-term gain from blasting the rocks near Delhi or Hyderabad for building contributes to current livelihoods and GDP (gross domestic product), but is at the cost of cultural, aesthetic, recreational and spiritual experiences of future generations *forever*. And these generations, let us hope, will be billions of people over thousands, if not millions, of years. To destroy such rocks manifests an extreme of blinkered and myopic philistinism.

As articulated, the precautionary principle does not fit, and is too weak for this context. There is no lack of certainty. And the term *cost-effective* leads us astray for two reasons: first, we are concerned with incommensurable values not susceptible to economic calculus; and second, discounting overvalues the clear short-term economic gains and ignores millennia of future benefits. To offset this weakness, much depends upon social and ecological responsibility, access to information, the exercise of imagination, and commitment to the democratic representation of future generations who, we must hope, will dramatically outnumber us, giving their interests a very high weighting.

Any broader formulation of the precautionary principle risks a comprehensiveness that could be used to support a conservationism that would discriminate against today's poor people. Nothing that follows should undermine the moral and practical case for participatory conservation (see, for example, Ghimire and Pimbert, 1997). The concern has to be a balance of the social and environmental, of values and actions, and of the present and future. Each of us might wish to think through and elaborate our own version of a revised precautionary principle. Here is mine:

> In the interests of poor people, future generations and the planet, where there are threats or certainty of serious or irreversible environmental damage or loss, neither lack of full scientific knowledge nor short-term economic gain shall be used as a reason for postponing preventive action that is socially and ecologically responsible. The more irreversible the damage or loss, the greater the urgency and the higher the cost justified to prevent it.

This formulation is a provocation for reflection, not final words, and surely for debate. Not least, there are questions of what is damage and what is social and ecological responsibility. There will also always be trade-offs. But this at least can be concluded: irreversibility is a practical concept; it needs more analysis and elaboration; and it should have more weight in decisions and actions. In understanding and applying it, the key is, perhaps, to struggle, and to struggle in every context and in every generation, and to act in ways which are responsible, socially and ecologically, both for the present and the future.

Cinderella concepts and criteria

In the contexts reviewed above – of settlement schemes and other bounded projects, of staff motivation and performance, and of the environment – ideas of *commitment*, *continuity* and *irreversibility* manifest themselves in different forms, with different implications. What stands out in common is that they have been relatively neglected as concepts and as criteria for weighing choices, for deciding what to do and for evaluation. As the restless search for novelty in development impels us to learn and use new words, concepts and criteria, old ones are buried and forgotten. This is the more so with these three since at no time have they enjoyed much popularity in development. They have been marginalized even more by the new prominence of the words which refer to power and relationships: empowerment, ownership, partnership, participation, accountability and transparency. Commitment, continuity and irreversibility have become more than ever Cinderellas, unrecognized and overlooked.[30] Yet, as I have argued, they are fundamental to good development practice.

Most surprising is the neglect of continuity of staff in post. It is easy to measure, which makes it odd that it is so rarely done. Part of the explanation may be that it is so often determined by personnel or human resource departments that are out of touch with field realities, or by central people in senior posts, or by politicians, or by combinations of these. One transfer can generate a chain of other transfers, multiplying its costs. The bad effects of one transfer can then be immense, though unseen, unmeasured and unrecognized. Too long in a post can also be bad, with loss of freshness and excitement; and there is a positive side to transfers – they can give a new clean start, re-energize and broaden experience. But all too often time in post is too short.

The neglect of commitment is less surprising. It is more abstract and not amenable to measurement. It is to be optimized, not maximized. Its dimensions are diverse: they can be personal – with commitment to, for example, an ideal, a cause or a relationship; or organizational – with commitment to a programme, project, a group of people or a mission; or political – with commitment to a programme or policy. Commitment is also contextual, evolutionary and difficult to forecast.

As for irreversibility, in economics it has been overshadowed by preoccupations with risk, uncertainty and sustainability. It has not been incorporated significantly into economic analysis. It is difficult to quantify and it confronts and contradicts conclusions that come from discounting. Nor is it always bad: as with continuity, more of it can be better or worse, depending upon the case. If factors like these explain why it has been such a marginal concept, the case is strengthened for offsetting them, developing it further as a concept and giving it more prominence.

Questions of commitment, continuity and irreversibility are relevant to much decision making and action. The issues they raise differ by context. It is tempting, then, to dismiss them as too vague and variable to be of much use. But there is a paradox here. For the very diversity of their meanings makes them versatile in their applications. The lesson is not to pass them by, but to define and apply them, context by context. They should be part of any checklist of criteria for review in formulating policies, making decisions and taking action. They deserve to be brought out of the shadows into the light closer to centre stage. Given more weight in development, and applied again and again, they should prevent or reduce damage from errors and, at the same time, ensure that more good things are done.

Notes

1 Mwea was so frequently visited by VIPs, researchers, school parties, women's groups, government officials and others that the manager told me he spent 45 per cent of his time on public relations. This led to the recruitment of a deputy manager for whom this was his major work.

2 The recent history of Mwea has been turbulent. During the late 1990s, farmers increasingly protested against the National Irrigation Board's corrupt management and high service charges. In January 1999, two young men were killed by police in a demonstration. The farmers took over the scheme to run it themselves (Kenya Human Rights Commission, 2000). This evidently failed, and, in January 2003, negotiations between the farmers' cooperative and the National Irrigation Board led to the formation of a committee to oversee the scheme (*Daily Nation*, 27 and 29 January 2003).

3 This section is from Chambers (1969, pp257–262). A few details of evidence have been edited out, together with a paragraph on Perkerra.

4 I struggled with my wish to change 'men' to 'people'; but have left the male-biased word, which was in the original. It situates the piece historically. This was before the gender-awareness revolution. That said, Jon Moris and Jane Hanger, the authors of the much-cited and influential Chapter H, 'Women and the household economy', in the Mwea collection (Chambers and Moris, 1973, pp209–244) deserve credit for showing how markedly settlement conditions made things worse for women, leading, for example, to a high rate of divorce.

5 Nicholas, in *Volta Resettlement Symposium Papers* p86, subsequently edited and republished in Chambers, 1970.

6 Interim report of a United Nations Special Fund survey of the lower Tana Basin in Kenya, as reported in *East African Standard* (Nairobi), 17 November 1965, and *Daily Nation* (Nairobi), 17 November 1965. Despite a long sequence of adverse appraisals, the project (named Bura) was eventually implemented and must rank as one of the economically most disastrous settlement projects ever.

7 The heading in the original text was 'Concluding'.

8 The word now would be appraisals. Evaluations are ex post, appraisal ex ante, but this distinction was not yet a convention in the late 1960s.

9 *Mea culpa.*

10 This section is taken from the final pages of Chapter M 'The Perkerra Irrigation Scheme: A contrasting case', in Chambers and Moris (1973, pp344–364). I would like to thank the past and present officials of the Kenya government who have helped me with the research for this case study. I am especially indebted to E. G. Giglioli, J. G. Stemf, S. G. Sandford and R. E. Wainwright for comments on an earlier version. Responsibility for what is written here is, however, entirely mine and should not be attributed to any other person or to any organization.

11 Attempts to obtain accounts or details of how Perkerra was financed have not been successful. There are reasons to infer that the cross-subsidization through the National Irrigation Board using surpluses from the more viable Mwea Irrigation Settlement continued until 1998, when the Mwea farmers rebelled; but I have been unable to substantiate this with direct, authoritative or numerical information.

12 According to one report, which remains unconfirmed, the Perkerra staff went unpaid for six months when the Mwea settlers rebelled and cross-subsidization of Perkerra from Mwea ended.

13 This equates to 1.5 million Kenyan shillings.

14 *Daily Nation*, 21 March 2003, http://www.nationmedia.com. This may have subsumed the earlier US$20,000 pledged by the National Irrigation Board.

15 This is not to justify the gross inequalities of landholdings in Zimbabwe. The government, however, chose not to take up aided programmes of settlement of the sort that had been so successful in Kenya. There were numerous reports of how farm labourers suffered and lost when land was seized.

16 In October 2003, *Concorde* had its historic last flight. The Mahaweli project is still alive, extensive and, to the best of my knowledge, well.

17 A contributory factor reflecting continuity of relationships may have been that the Tanzanian President was a Finnophile. The only place in Tanzania with a sauna bath was, and to the best of my knowledge remains, Mtwara. Though its construction provoked a divisive ideological debate among Finnish expatriates, it could hardly have been a political liability when it was patronized, as it was, by the president.

18 Statistics for DFID aid to Uganda compiled by Lister and Nyamagusira (2003) from www.DFID.gov.uk/sid for 1999/2001 and 2000/2001, respectively, give project aid dropping from UK£41.467 million to UK£17.686 million, and programme aid rising from UK£17 million to UK£45 million. The possibility must be recognized that part of this dramatic contrast may have been the result of a change in accounting.

19 To be wilfully unaware is to decide not to know or not to take steps to know, when it is apparent that there is something discordant to understand. Most people do this from time to time. I certainly do.

20 Hanging in and patience can bridge gaps until fashions come back in again. My grandmother's long skirts were for long a legacy of the past, but became *avant garde* fashion when hemlines dropped again, and casual observation suggests that, in 2003, for some young women at least, flared trousers have come back. Those aided projects that survive may in due course find themselves part of a wave of the future.

21 USAID's lack of long-term commitment and tendency to lurch from one priority and language to another is a commonplace development experience, has done much hidden damage and deserves a special study. An example is its policies towards family planning. In Jordan, for example, support to a project was withheld after field preparations had begun. 'In such situations, with expectations raised at the local level, organizational credibility is diminished, and time and energy must be spent to regain the trust of partners in the field' (bint Talal, 2003, p190).

22 I owe the word friendship to Norman Uphoff, who frequently stresses it in Gal Oya (Uphoff, 1992), and to Elmer Ferrer at the Community-based Coastal Resources Management Festival, held at Subic Bay in the Philippines in June 2003, who eloquently stressed how friendship had been fostered by people from different backgrounds and organizations staying together for a long time, working with a common cause.

23 Rosalind Eyben (pers. comm.) has pointed out that: 'Interestingly, the FCO [Foreign and Commonwealth Office of the UK government] now has "anchors", so although someone is only posted for three to four years at any time to a particular country, they do go back again later on and possibly for a third time, as well, during their career. Diplomats appreciate the importance of local knowledge much more than do aid staff.'

24 While courting my wife Jenny, I was in Bihar when she had an excellent job offer that would have put us in different continents for two years. Forced to communicate by cable with few words, I pleaded with her to 'minimize irreversibility commitment'. To my great good fortune, though not necessarily hers, it worked.

25 I write this with passion, anguish and guilt. One of the biggest, most selfish errors of my life was to spend many of the Sundays during three and a half years living in New Delhi rock-climbing on endangered rocks at Damdama and Dhauj, instead of devoting my time to saving them and their environments for future generations. The finest rocks are still, but precariously, intact at the time of writing (2004); but at Dhauj outlying rocks have been mindlessly quarried and destroyed for-

ever. In Hyderabad a vigorous Society to Save Rocks has done great work; but to my knowledge there is no equivalent in Delhi, or, indeed, in any other city in the world.

26 For a discussion of substitutability and well-being, see Alcamo et al (2003, pp79–81).

27 I was lucky to be involved both in drafting the chapter on human well-being and in plenary discussions across the whole range of subjects. This was one of the most stimulating and mind-opening experiences of my life.

28 I will be grateful to anyone who can contradict or qualify the assertion that irreversibility remains underdeveloped as a concept.

29 Caution is needed here in distinguishing cases. Some groundwater can be renewed in an almost linear manner. However, restoration to a former condition implies a reversibility that is not characteristic of ecological systems. Depletion, as through overfishing, may take an ecosystem below a threshold of resilience, so that 'recovery' is very slow or follows a pathway to a different species composition and community structure. In Newfoundland fishery, the failure of cod to recover quickly is an illustration of this (David Schoeman, pers. comm.).

30 The Cinderella analogy works as a metaphor for exclusion by those with power and influence. Her ugly sisters did this to Cinderella. Ugly in this sense myself, I was responsible for excluding 'continuity of staff in their posts' from the prescriptions of an IDS (Institute of Development Studies) policy briefing paper on power, procedures and relationships (Chambers et al, 2001), as I recollect murmuring that continuity was 'old hat'.

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7

Well-being and Ill-being: The Good and the Bad Life

D. Narayan, R. Chambers, M. K. Shah and P. Petesch

Well-being is Multidimensional

A better life for me is to be healthy, peaceful and to live in love without hunger. Love is more than anything. Money has no value in the absence of love.

A 26-year-old woman, Dibdibe Wajtu, Ethiopia

The starting question posed by the researchers to the small group discussions with poor women and poor men is, 'How do you define well-being or a good quality of life, and ill-being or a bad quality of life?' From these discussions emerge local people's own terminology and definitions of well-being, deprivation, ill-being, vulnerability and poverty. The terms well-being and ill-being were chosen for their open-ended breadth, so that poor people would feel free to express whatever they felt about a good life and a bad life. 'We are trying to present a new way of seeing well-being', notes a researcher. It is the way poor people see it themselves.

Poor people's ideas of a good quality of life are multidimensional. As explored in Part I of this chapter, they cluster around the following themes: material well-being, physical well-being, social well-being, security, and freedom of choice and action. All of these combine pervasively in states of mind as well as body, in personal psychological experiences of well-being. Much of ill-being was described as the opposite of these. Part II examines these dimensions in turn: material deprivation; physical ill-being; bad social relations; vulnerability, worry and fear, low self-confidence; and powerlessness, helplessness and frustration. Part III describes the psychological dimensions of well-being and ill-being. In describing the conditions of their lives, poor children especially express resentment.

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Part I. Well-being: The Good Life

How poor people put it

Ideas of well-being are strikingly similar across the range of participants. Despite differences of detail, and contexts that are diverse, complex and nuanced, the commonalities stand out. The same dimensions and aspects of well-being are repeatedly expressed, across continents, countries and cultures, in cities, towns and rural areas alike. And they are expressed by different people – women and men, young and old, children and adults.

For women in Tabe Ere in rural Ghana well-being means security: being protected by God, having children to give you security in old age, having a peaceful mind (*tieru villa*), patience (*kanyir*, meaning not holding a grudge against anyone), and plenty of rain.

To have most, if not all, of the necessary basics of life is *umoyo uwemi* and *umoyo wabwino*, well-being as described by different groups in Malawi. These basics include certain assets, adequate food, decent medical care, constant and regular sources of income, nice clothes, good bedding, a house that does not leak, a toilet, a bathroom, a kitchen, healthy bodies, couples being respectful of each other, being God-fearing, having well-behaved children who are not selfish and having peace of mind.

For those in Khaliajuri in rural Bangladesh having a good quality of life means having employment for the whole year, a good house, four or five cows, a fishing net, good clothes to put on, food to eat to one's heart's content and being able to protect one's house from flood erosion. Middle-aged women say that for a good quality of life there should be a male member of the household earning money, a son for every mother and no husbands pursuing polygamy.

A participant from Renggarasi in rural Indonesia considers a person to be living well who can secure his family's needs with produce from his livestock and who is able to help others who need material and non-material things or advice.

In Nigeria well-being is described by different people as being a responsible person who has a pleasurable life, peace of mind, security and independence, and who is popular with the people, is able to marry easily, is able to educate children, is able to patronize private clinics and schools, and who has money, land, a house and good clothes.

In Bulgaria the major distinctive feature of well-being is stable employment, which means having money as well as security. The National Synthesis Report notes that the family is another important aspect, along with being able to socialize and being in harmony with oneself. The wealthy, seen as those who have and flaunt money and power, do not necessarily have the respect and security that the community considers essential parts of well-being.

In the Kyrgyz Republic, 'informants understand well-being as good life and wealth; however, they do not think that well-being is limited to these tangible components, and believe that well-being is impossible without tolerance, peace, family and children. The informants think that the basis of well-being is good health, peace in the family and in the society; in their opinion, wealth, which is an important component of well-being, can only be gained if these conditions are present.' From the Kyrgyz Republic it is also reported that most of the informants define well-being as 'stability on a household and society level and ability to satisfy one's material and spiritual needs'.

In Barrio Las Pascuas in urban Bolivia, a group of youths say that those who have a good life are 'those who do not lack food', and those 'who are not worried every day about what they are going to do tomorrow to get food for their children. They have secure work, and if the husband does not work, the wife does.' In Nuestra Señora de Guadalupe in another part of urban Bolivia young men say that, besides having adequate food and work, well-being is to be friendly and to have friends, to have the support of family and society, and 'to be patient, and above all happy'.

Materially, enough for a good life is not a lot

> *I would like to live simply. I don't like houses with too much inside. To have a bit more comfort. Nothing big … I would like a simple house … not big, or luxurious … a simple house with a floor.*
>
> A 21-year-old man, Esmeraldas, Ecuador

It is perhaps part of the human condition to aspire not for the moon, but for imaginable improvements. Participants were clear that enough materially for a good life for them was not excessive or unrealistic (see Box 7.1). They hope for moderate, not extravagant, improvements. They do not see substantial wealth as necessary for well-being. Rather, they express the material dimension of life in terms of having enough for a reasonable level of living. And the material is only one dimension among others.

It is not just that poor people's material aspirations are modest. It is also that the worse off they are, the more a small improvement means. A little then means a lot. This may apply especially with women who so frequently have so little. For women in two Malawi rural sites part of a good life is having adequate utensils, especially pails for drawing water and a rack for drying plates. To a discussion of well-being in Bangladesh, a group of older women add, 'Those who could pass time for the prayer of God after taking a full meal and could sleep on a bamboo-made platform live a good quality of life.'

None of this justifies modest ambitions in development, accepting the horizons of poor people where these are limited, or restraining efforts to help them and to help them help themselves. To the contrary, it hugely reinforces the case for giving overwhelming priority to their well-being as they envisage it. Gains by poor people should come first. When the objective is to enhance the well-being to which poor people aspire, the benefits from small changes can be large indeed.

Box 7.1 *The good life, caring for children*

To be well is when you have money, and you have a family and children. You need to have savings in order to be able to support your children till later on in life.

A young man, Bulgaria

A good life is to have enough food and clothing for my children. To educate them to be self-reliant when we get retired.

A man, Mitti Kolo, Ethiopia

The rich manage to send their children to school and also … to take their children to the clinic.

A man, Musanya, Zambia

To be well means to see your grandchildren happy, well-dressed and to know that your children have settled down; to be able to give them food and money when-ever they come to see you, and not to ask them for help and money.

An old woman from rural Bulgaria

Material well-being: having enough

> *But at least for each child to have a bed, a pair of shoes, a canopy over their heads, two sheets – not to sleep like we do on the ground.*
>
> Ana Maria, a poor woman, Esmeraldas, Ecuador

> *A poor person is a person who does not own anything that provides him with a permanent source of living. If a person has a permanent source of income, he will not ask for other people's assistance.*
>
> A poor woman from Sidkia, Egypt

Three aspects of material well-being that are repeatedly mentioned are food, assets and work.

Food

Adequate food is a universal need. In Malawi hunger is ranked as the number one problem by nearly every discussion group in the three urban and seven rural communities participating in the study. Elsewhere – across the range of countries – enough to eat every day is again and again stressed as a feature of well-being. In contexts as different as Bangladesh, Bulgaria and Zambia well-being included being able to have three meals a day, all year round. Food security too is a critical component, with the number of months of food security given frequently as a criterion for ranking well-being, particularly in Vietnam.

Assets

For those living in rural areas secure tenure of adequate resources, especially land, is another nearly universal criterion of well-being. This often includes ownership of livestock. In urban areas the parallel needs are savings and capital, and access to consumer goods. In urban Ghana well-being is identified with capital to start a business. The need for housing – as well as furniture, utensils and tools – is also a virtually universal aspect of well-being and sometimes poor people describe a 'house that should not let in the rain'.

Work

Work to gain a livelihood is a nearly universal aspiration among participants. Money itself is mentioned less frequently than one might expect and, when mentioned, it is implied by other aspects of well-being such as the ability to find paid work to obtain money, to buy clothes and to pay for health treatment and school expenses. A poor man in Thompson Pen in Jamaica says, 'Work makes all the difference in the world. I feel bad, miserable, sick, and can't take doing nothing. My wife, at 78, is still working. My dream is a little work to make ends meet.'

In rural areas work takes many forms; it is usually agricultural and linked with land. In urban areas it means a steady job, which is stressed again and again by those who are without work or who are striving to make a livelihood through casual labour or informal and illegal activities. Whether it is Malawi, where one idea of well-being is both husband and wife working, or Russia, where participants stress the importance of wages that are regularly paid, the desire is for productive work to provide an adequate and secure livelihood.

Bodily well-being: being and appearing well

Material well-being is rarely mentioned without other critical aspects of a good life. These include the bodily well-being of health and appearance, as well as a good physical environment.

Almost everywhere, health and access to health services – whether informal or formal – are important. A healthy and strong body is seen as crucial to well-being – not just for a sense of physical well-being in itself, but as a precondition for being able to work. A person who is sick and weak cannot work or cannot work well.

For some, especially for girls and young women, the importance of appearance – of both body and clothing – comes through forcefully. Quality of skin is often referred to. In Muchinka in rural Zambia the bodies of the better off are said to 'look well'. For urban poor people in Jamaica criteria for well-being include 'skin tone looks balanced' and 'looking well fed'. In Gowainghat, Bangladesh clothes, oil for the hair and soap are important to young women. Across cultures and contexts being able to dress well and appear well is repeatedly stated as part of a good quality of life.

The third dimension of physical well-being is physical environment, with well-being in Accompong, Jamaica associated with, for example, 'the fresh air in the hills of Cockpit County'. The aspect of physical environment, however, is more often used in a negative context and is described, for example, as the bad experiences of living in 'the places of the poor'.

Social well-being

Social well-being includes care and well-being of children; self-respect and dignity; and peace and good relations within the family, community and country.

Being able to care for, bring up, marry and settle children

In Nigeria, of the 48 aspects of well-being identified, no fewer than eight of them refer to children. Having happy and healthy children, feeding them, clothing them, being able to take them for treatment when sick, and being able to send them to school and pay school bills are common concerns strongly expressed. In Bangladesh households that are financially well off are those that can afford clothes and education for their children.

To be able to marry and settle children is a frequent aspiration. In Malawi and Uzbekistan wedding ceremonies conducted in good style are important. In Ampenan Utara, Indonesia one of the criteria for differentiating well-being groups is the ability to meet the costs of children's weddings: the top group has no problem; the second group can meet the cost; the third has to become indebted to meet the costs; and the issue for the bottom group is simply not mentioned. Landless women in Dorapalli in India identify a major impact of poverty as 'difficulty in marrying girl children'. In Eil-bil-ille, Somaliland the well off are those who can afford marriage-related costs and who always marry at an early age.

Self-respect and dignity

Self-respect and dignity, as described by poor people, means being able to live without being a burden to others; living without extending one's hand; living without being subservient to anybody; and being able to bury dead family members decently. In Nigeria this includes being listened to, being popular and being able to fulfil social obligations and to help others.

Peace, harmony and good relations in the family and the community

Many poor people consider the absence of conflicts essential for family and social well-being. In Ghana this is expressed as unity in the household or community. In Uzbekistan it means peace and calm in the family, in the country and in one's own community.

Good relations extend to social cohesion and support, and to helping one another. In Vietnam near Ha Tinh poor people state their priorities as being able to 'encourage people to visit, support and give presents (show feelings in general) to households dealing with crises and during the holidays'.

Security

Security includes predictability and safety in life and confidence in the future.

Civil peace

A group of elderly residents of Ak Kiya in the Kyrgyz Republic comment, 'Among all well-being criteria, peace is the most important one. Now there is war in Yugoslavia and in other countries. God willing, it would not happen here. As they say, "be hungry but live in peace".' Even in contexts without recent experience of civil conflict or war, such as this one in the Kyrgyz Republic, civil peace was often ranked high. Peace – the absence of war, violence and disorder – is the most important component of well-being for those living in the context of recent war or disorder.

A physically safe and secure environment

Well-being means not being vulnerable to physical disasters, threats and discomforts that are so typical of the places of poor people. These included floods in urban Argentina and rural Bangladesh, wild animals in Sri Lanka and India, water pollution from industry in Bulgaria, the disaster from the Aral Sea in Uzbekistan, and air pollution from industry in Olmalyq, Uzbekistan. These are named among many other physical, often seasonal, threats.

Personal physical security

'Here we live with our door open', report participants in rural Argentina. A man in Jamaica says that 'this is a ghetto community, but you don't have any violence; you can walk (around) here any hour of the night and no one is going to harm you'. Again in Jamaica, the relaxed atmosphere and the high level of personal safety in the countryside are valued.

Lawfulness and access to justice

Refugees in a Russian city who survived the horror of a civil war and genocide and who were objects of constant abuses describe 'peace' and 'the absence of constant fear' as the main prerequisites of a good life. Lawfulness and access to justice are widely seen as aspects of well-being, particularly in Nigeria. Security from persecution by the police and other powers that be is a priority for many, especially for urban vendors.

Security in old age

Particularly for older people, security and support in old age are a primary concern. An old woman in Khaliajuri, Bangladesh says that, for a good quality of life, a son must not sever the family bond after marriage and he must provide food to his mother.

Confidence in the future

The good life is also frequently defined as being able to look forward to the future. Especially in countries like Bosnia and Herzegovina and Russia that have experienced recent national traumas participants value being able to have confidence in a stable and predictable future. They say that they once had this, but that it is now only experienced by a few rich people.

Freedom of choice and action

The research team from Brazil puts it like this:

> People tended to equate poverty with powerlessness and impotence, and to relate well-being to security and a sense of control of their lives. A woman from the community of Borborema established a connection between power and control, and well-being. She argued, 'The rich one is someone who says, "I am going to do it", and does it.' The poor, in contrast, do not fulfil their wishes or develop their capacities.

Freedom of choice and action extends to having the means to help others. Being able to be a good person is a feature of the good life that poor people often highlight. A young man in Isla Trinitaria, Ecuador wants to be able to buy clothes for his sisters. In Malawi a good characteristic of one high category of well-being was to love everyone and help others when they have problems. Well-being is quite frequently linked with moral responsibility, with having the wherewithal to help others, and with having enough money to be able to give to charity or a religious organization.

What people say they wish to be able to do covers a huge range: to gain education and skills; to have mobility and the means to travel; and to have time for rest, recreation and being with people – among others. Underlying all of these – and the material, physical, social and security dimensions – is a fundamental aspiration. Participants in many contexts say that they want to be able to make choices, to decide to do basic things without constraint, to live in a predictable environment and have some control over what happens.

Diversity by context and person

For all of these commonalities, there are differences of aspiration and of concepts of well-being. They vary by continental region, by rural and urban areas, by livelihood, by age and by gender.

The contrasts are perhaps not surprising, but listing a few of those that are more striking can make and illustrate the point without any attempt to be comprehensive:

- In Eastern Europe, Central Asia, Bulgaria, the Kyrgyz Republic, Russia and Uzbekistan, well-being is frequently defined nostalgically as the 'normal' condition, meaning before the end of communism. In Russia well-being criteria are taken from the past and not the present.

- Among pastoralists, whether Somalis in Somaliland or Kalmyks in Russia, well-being is often intimately linked with animals.
- Poor rural people emphasize land and livestock, farming capital and inputs for livelihood activities, and being able to farm on one's own.
- Poor urban people repeatedly emphasize employment, a job, infrastructure, housing, security of tenure and physical security. They sometimes have higher material aspirations for consumption goods than rural people. In one urban site in Malawi participants say that well-being entails leading a European (Western) life (*moyo wachizungu*), having houses to rent out to others, having decent and well-paying jobs and having very good houses with electricity.
- Women tend more often than men to mention peace in the family; good social relations in the community; adequate and nutritious food; good drinking water; being able to bring up children in good conditions, keep them healthy, and sending them to school; and not being maltreated in the family.
- Men tend more often to mention material productive goods, and time to relax. There are exceptions to these generalizations, and there is a danger of over-stereotyping gendered priorities and values, especially at a time when change in gender roles in many places is rapid.
- The views of some poor children were asked. In Chittagong, Bangladesh, according to children, well-being means having neat and clean surroundings, with facilities for education, being able to play freely, living in a building, having good food (fish, meat, vegetables, etc.), going every morning to madrasa (traditional Muslim school), and everybody living in harmony. Peace and harmony in the family and in society are important to children.

Wealth and well-being are different

In discussions on criteria for a good life, the researchers report:

- 'The group of young people underscored the need to have a family, to feel supported and understood.' – According to a youth group in Barrio Universitarios, Bolivia
- In Bulgaria, 'wealth and well-being are not identical, for the rich have money but don't have security, nor are they respected by the community. Ill-being is, however, identical with poverty: this is "our situation".'
- In Russia, 'the life of the well-to-do people was never called a "good life". Ultimately, when both the younger and older participants talked about the well-to-do people, they would never call their life a "good" one.'

Good living or well-being in Zambia, 'can mean being liked, but also can make others jealous and bring hatred and death'. Participants repeatedly distinguish between wealth and well-being. Those who are wealthy are by no means always in the top category for well-being. For example, a widow who is rich might not be put in the top well-being category because widowhood is a bad condition.

The wealthy can be generous and good, but often they are seen in a bad light. A 54-year-old man from Kok Yangak in the Kyrgyz Republic says:

> One can make a fortune, but if it has negative effects for the rest of the community, such wealth gives just an illusion of well-being, because it does not do any good for people. If somebody's well-being is based on the ill-being of others, it is not a true well-being. There are rich people in the village. They made their fortune by selling alcohol and vodka. The community does not like these people, because their prosperity is only possible due to the growing problem of alcoholism in the village.

In contrast, poverty and non-material well-being can sometimes be found together. In rural Accompong in Jamaica the researchers write that 'the lives of all citizens are impacted by this peace within the neighbourhood. Despite hard times and obvious poverty among most of the households an open welcome and hospitality to visitors and strangers to the community gives a distinct feeling of well-being and a good quality of life.'

Part II. Ill-being: The Bad Life

> *The family was housed in a thatched hut and there was no way that they could have two square meals a day. The lunch would be finished by munching some sugarcane. Once in a while they would taste 'sattu' (made of flour), pulses, and potatoes, etc., but for special occasions only. During the rains the water used to pour down the thatched roof and the family would go to seek cover in the corners to avoid getting wet. Their clothing would be of coarse material and they would content themselves with one or two pairs of clothes for a year. The wages then used to be paid as 1kg of grain per day. After three years of marriage, unable to bear the harassment of the mother-in-law, both Nagina Devi and her husband separated from her.*
>
> **A poor mother, Manjhar, India**

Ill-being and the bad life bring with them different sorts of bad experience. These are many and interwoven. Some correspond to the opposites of the clusters of well-being: lack and want are material; hunger, pain, discomfort, exhaustion and poverty of time are physical; bad personal relations, exclusion, rejection, abuse, isolation and loneliness are social; vulnerability and fear relate to insecurity; and helplessness, frustration and anger reflect powerlessness. It is also striking, though, how much of the bad life they miss, for there are others that flow from and feed them: loss, anguish, grief, humiliation, shame, and persistent anxiety, worry and mental distress. Box 7.2 features selections from poor people's definitions and criteria of ill-being.

Box 7.2 *Expressions of ill-being*

The words and expressions used for the bad life are naturally different in different language groups, countries and continents. A selection gives a sense of the range.

Ill-being and well-being have close equivalents in Spanish-speaking Latin America – *malestar* and *bienestar*. *Malestar* is a common word in Spanish, meaning a sense of unease or discomfort, which can be physical, social or psychological. It is not a synonym for poverty (*pobreza*). In urban Argentina, the words *situatión crítica* (critical condition), *vida complicada* (a complicated life) and *malaria* (situation where everything has gone wrong, total scarcity) are also used.

In Bolivia, *tristeza* (sadness), the opposite of *felicidad* (happiness), is used for ill-being, based on pictures of a sad face and a happy face, to which participants were invited to react.

In Malawi, *ukavu* means a state of constant deprivation. It is explained that households described in this group lack peace of mind because they are always worried about how to make ends meet. In most *ukavu* households, couples quarrel and fight a lot because they desire good lifestyles (*umoyo uwemi*), but they lack the means. 'It is not surprising that most men from these households are drunkards because they drink to forget home problems.'

Women from Mbwadzulu village in Malawi say that they consider it ill-being when 'people sit on the floor … people going to their gardens without taking any food … they have no latrines; they cook under the sun [have no kitchen], have no pit latrines, no change house [bathing place outside the house, constructed from grass] and no plate drying rack'.

In Buroa, Somaliland extreme ill-being is defined as the experience of war and famine.

In India, the word *dukhi* (and in Bangladesh *asukhi*), the opposite of *sukhi*, is close to ill-being, unhappiness, a bad condition of life in terms of experience, whether material, social or psychological.

In Chittagong, Bangladesh, ill-being is *asukhi* (unhappy) or *kharap abstha* (bad condition), the opposite of *bhalo abstha* (good condition).

In Bulgaria, one aspect of ill-being is a pervasive sense of loss, of moving backward in time to an earlier century – from cultivation by tractors to having to cultivate by hand, from buying soap and bread to having to make and bake your own. This is described as going wild (*podivyavane*), being obliged to work in a manner considered humiliating, uncivilized and inefficient.

Box 7.3 *The Bad Life in Ethiopia*

The following are literal translations of phrases used by poor men and women in Ethiopia to express their state of ill-being.

'We are left tied like straw'
'Our life is empty; we are empty-handed'
'Living by scratching like a chicken'
'What is life when there is no friend or food'
'Life has made us ill'
'We are skinny'
'We are deprived and pale'
'We are above the dead and below the living'
'Hunger is a hyena'
'The poor is falling, the rich is growing'
'A life that cannot go beyond food'
'We simply watch those who eat'
'Difficulties have made us crazy'
'We sold everything we had and have become shelter-seekers'
'It is [like] sitting and dying alive'
'My relatives despise me and I cannot find them'
'Life is like sweeping ash'
'From hand to mouth'
'A life that is like being flogged'
'A life that makes you look older than your age'
'Just a sip and no more drop is left'
'If one is full, the other will not be full'
'Always calf, never to be bull'
'We have become empty like a hive'

The multidimensionality of ill-being

As with well-being, participants describe ill-being as multidimensional. The most frequently mentioned dimensions of ill-being correspond closely to dimensions of well-being. The bad life is marked by many bad conditions, experiences and feelings. Box 7.3 illustrates the range of expressions that poor men and women from Ethiopia used to describe the bad life.

Material lack and want

Food

The most frequently mentioned want or lack is food. In every country poor families report that they miss meals. They often only eat once a day and sometimes have nothing for days on end. A saying in Ethiopia is, 'If one eats breakfast, there is no supper.' Hunger is highly seasonal in rural areas. In urban Russia it peaks towards the end of the month, before pay, when there can be days with an absolute lack of food. In many rural areas the poorest people rely on wild foods. Provision of food for children is a constant worry for parents, who themselves stint and starve. A mother in Nuevas Brisas del Mar, Ecuador says, 'In the last two years our children leave for the school without having coffee. Sometimes I have some money but if I fix them some breakfast there is not enough for lunch.' Urban starvation is less dramatic or obvious than that in rural areas, but poor people in Jamaica say it is more prevalent. In urban areas in countries that have undergone severe restructuring crises, study teams were shocked to learn of a quiet, hidden urban starvation. Some who starve are too proud and decent to beg or steal. In Ivanovo, Russia, 'a woman told us that sometimes she did not have food for several days and was only drinking hot water and lying in bed so as not to spend energy'. In Ethiopia a 30-year-old married man in Kebele 10 says, 'We eat when we have, and we go to bed hungry when we don't.'

Livelihood, assets and money

Uncertainty of livelihood sources and employment is virtually universal. Returns to work are low. Casual labour is both uncertain and badly paid. Insecurity from lack of assets and money is often mentioned, but more often implied. Money is needed for access to many services, especially health, education and transport; for bribes and fines; for daily necessities and often subsistence; for social occasions; and for clothing. Poor, ragged, second-hand and worn clothing is repeatedly given as a mark of being badly off. High-interest debt is common. Many needs and wants trace back to the lack of money.

Housing and shelter

Virtually everywhere, shelter and housing are a source of discomfort and distress. Shacks, huts, houses or tenements are small. Many people crowd into small spaces. Possessions are insecure. Huts and shanties leak and flood, fall down, blow down, burn down or are knocked down. People have to stand when the ground gets wet. Dirt, filth and refuse are always there. Urban sanitation is often non-existent or disgustingly bad. Sewers – where they exist – sometimes overflow and flood into huts, and health suffers as a result.

Physical ill-being

Hunger, pain and discomfort

The physical ill-being of hunger and sickness, and the pain, stress and suffering they bring, are a common theme. Women in a group in Nigeria do not have sufficient breast milk to feed their babies. In Bedsa, Egypt an older man says, 'Lack of work worries me. My children are hungry and I tell them the rice is cooking, until they fall asleep from hunger.' In Ethiopia there is 'burning hunger' and 'fire of hunger'. Poor people are more often sick and injured, and are often sick for longer, and treated, if at all, later than the non-poor. The reasons are many. Sickness itself is a frequent cause of suffering and impoverishment, leading to physical weakness, dependence and disability. Finally, poor people live in discomfort, in unhygienic, dangerous, dirty, badly serviced and often polluted environments where they are vulnerable to many physical shocks, stresses and afflictions.

Exhaustion and poverty of time

The sheer exhaustion and lack of energy many poor people experience is easily overlooked. For many, their body is their main or only asset. It is uninsured. Shortage of food and sickness not only causes pain, but also weakens and devalues the asset. Those short of food are badly stressed by hard work. There are 'lazy' poor people, but inactivity is often conservation of energy. Poor people are often described as tired, exhausted and worn out.

The increasing burdens of their expanded roles are driving many women deeper and deeper into physical exhaustion. These burdens also expose them to 'time poverty', meaning that they have little or no time to rest, reflect, enjoy social life, take part in community activities or spend time in spiritual activities. Whereas men are often increasingly out of work, women are under more pressure.

Bad social relations: exclusion, rejection, isolation and loneliness

Exclusion takes many forms. Ignorance of or lack of fluency in a dominant majority language can be excluding. Minority groups around the world share the linguistic exclusion of women in Guadalupe, Bolivia who do not participate in public community activities because they feel embarrassed to speak their native language, Quechua. Denial of education can be excluding. The parents of Um Mohamed, a girl in El Gawaber, Egypt, forced her to leave school: 'They sentenced me to death when they did that.' In Brazil there is exclusion when parents try to enrol their children in public schools and are unable to find places for them.

Rejection is associated with poverty in many ways. The extremely poor are often rejected, even by those who are also poor. Two other forms of rejection are the abandonment of children and of old people. The feelings of rejection, isolation and loneliness are most often cruelly inflicted on those who suffer most in other ways.

Loneliness and lack of social support are no longer an uncommon experience of poor people generally, particularly the elderly. Those with little social support are described as being 'poor in people'. In rural Bulgaria, an old woman says, 'Young people have nothing to do here. You can't imagine how I feel, as lonely as the dawn, but I was the first to prompt them to move to the city. I would have felt even worse watching them waste their lives here.' Old men in Mbamoi, Nigeria say, 'We poor men have no friends. Our friend is the ground.' This isolation is most acute for those who are very poor indeed and for those who are too weak to be able or to wish to assert themselves, especially the old. In Nuevas Brisas del Mar in urban Ecuador, where the team shared a meal with participants, an old man who had been present for three days and had hardly taken part at all was identified as 'the voice of those without voice, the voice of hunger'.

Self-exclusion occurs when inclusion is seen as dangerous or bad, and is a cost of a violent or abusive environment. Says a woman in Dock Sud, Argentina, 'Now I am with my grandson. He is seven and the teachers in kindergarten tell me I have to let him be with other boys, but what for? To be a drug addict when he grows up? Here there are kids that are eight years old who do drugs, and after that they start to rob. No, I'd rather see him alone, isolated, like they say in school, but I'd rather have him at home with me; I take care of him.'

Self-exclusion also occurs for reasons of shame. A poor person may not be invited to a wedding. If invited, a poor person may decide not to go because of being unable to appear and behave appropriately. Many of the self-excluded are the 'invisible poor', especially the 'new poor' who will not confess that they are poor. In a city in Bulgaria a poor man comments, 'There was a man in our apartment building. A silent, shy fellow, always very neatly dressed. They found him dead in his apartment. The doctor said that he had become so feeble that he died of a common cold; they found just a piece of stale bread in his flat. It's a pity we never spoke with him. He had dignity, that fellow.'

Insecurity, vulnerability, worry and fear

> *There's great insecurity now. You can't make any plans. For all I know, tomorrow I might be told that we'll be laid off for a couple of months or that the factory is to shut down. We work three days a week even now, and you're in for a surprise every day.*
>
> Participant, discussion group of men and women,
> Kalofer, Bulgaria

> *I am going to be poor and even hungry if I cannot labour in the coming years due to old age.*
>
> A resident, Ha Tinh, Vietnam

Insecurity and vulnerability are deeply embedded in the bad life. Insecurity comes through exposure to mishaps, stresses and risks – to dangers in the physical environment, in society, in the economy and in the administration and legal systems. Vulnerability comes because poor people are defenseless against damaging loss. Together these generate worry and fear: of natural disaster, of violence and theft, of loss of livelihood, of dispossession from land or shelter, of persecution by the police and powers that be, of debt, of sickness, of social ostracism, of the suffering and death of loved ones, of hunger and of destitution in old age.

Lack of confidence is frequently mentioned as a result of poverty. In Bosnia and Herzegovina, the inability to find a job makes people feel worthless to themselves and their families.

Powerlessness, helplessness, frustration and anger

Again and again, powerlessness seems to be at the core of the bad life. In Russia it is articulated as a complete sense of political impotence. More generally, powerlessness is described as the inability to control what happens, the inability to plan for the future, and the imperative of focusing on the present. In Zawyet Sultan, Egypt the condition known as *el-ghalban* and *ma'doom el hal*, words used for the poorest, mean helplessness and having no control over sources of one's living and therefore no control over one's destiny.

Time horizons are then short. Young people in Kalofer, Bulgaria say, 'Each day is unpredictable – you can't make any plans, don't know what you're in for tomorrow.' The sense of impotence is compounded when the future is seen as getting worse. Urban youth in Esmeraldas, Ecuador are reported as saying, 'You can't think of the future because you can only see how to survive in the present.' The report continues to say that everybody in the group agrees that in the future there is only going to be more poverty. At this stage the facilitators had to stop the meeting because the youth got fed up.

Poor people want to be able to take the long view, but they cannot. Having to live 'hand to mouth' is not a choice, but an immensely frustrating necessity. The experience is daily anxiety, and having to eat the moment they receive food or money.

Worry about the future, especially the future of children, coexists with concerns for the immediate present. According to the report of an interview with a woman in Pedda Kothapalli, India, 'She is worried about the future of her children and the struggles they have to face once they grow up. Her immediate concern is to which house she should go for a loan of some food grains for their food that day.'

Part III. Psychological Experience of Well-being and Ill-being

The experience of well-being and ill-being is inextricably psychological. The dimensions of good and bad quality of life contribute to and are part of good and bad states of mind and being.

The experience of well-being: peace of mind, happiness and harmony

> *Being well means not to worry about your children, to know that they have settled down; to have a house and livestock and not to wake up at night when the dog starts barking; to know that you can sell your output; to sit and chat with friends and neighbours. That's what a man wants.*
>
> **A poor man, Bulgaria**

Interwoven with other dimensions of well-being – material, bodily, social, security, and freedom to choose and act – is psychological well-being. This is variously expressed as happiness, harmony, peace, freedom from anxiety and peace of mind. From Novi Gorodok, Russia comes, 'Well-being is a life free from daily worries about lack of money'; from Gowainghat, Bangladesh, 'to have a life free from anxiety'; from Nova Califórnia, Brazil that quality of life is 'not having to go through so many rough spots' and 'when there is cohesion, no quarrels, no hard feelings, happiness, in peace with life'; from Nigeria, 'well-being is found in those that have peace of mind, living peacefully. It is to be filled with joy and happiness. It is found in peace and harmony in the mind and in the community.'

For many, too, a spiritual life and religious observance are woven in with other aspects of well-being. Poverty itself could get in the way. An old woman in Bower Bank, Jamaica says, 'I got up this morning and all I want to do is read my Bible, but I share a room with my son and my grandchildren and all they do is make noise, I can't even get a little peace and quiet.' In Padamukti, Indonesia being able to make the pilgrimage to Mecca means much, as does having *sholeh* (dutiful and respectful) children who will look after their parents in old age and pray for them after they are dead. In Chittagong, Bangladesh part of well-being is 'always [being] able to perform religious activities properly'. For older women in Cassava Piece, Jamaica, their church gives them a spiritual uplift and physical support. The importance to poor people of their sacred place – holy tree, stone, lake, ground, church, mosque, temple or pagoda – is repeatedly evident from their comparisons of institutions in which these frequently ranked high, if not highest.

The experience of ill-being: humiliation, shame, anguish and grief

Experiences of ill-being can be seen to combine and to compound each other in bad states of mind and being. Some connections stand out strongly. It is striking how often participants raise aspects of mental distress when describing the effects of poverty. Women in Tabe Ere, Ghana, for example, connect poverty, anxiety, begging, shame, isolation and frustration. They explain that poverty creates 'too much pressure on individuals and often renders a person mad with worry and anxiety'. Begging is seen as a degrading activity, which brings about insult and disgrace to the family. This results in shyness within the community that in turn leads to frustration in life. Participants in different countries speak of mental stress and breakdown, depression, madness and suicide, together the antithesis of the well-being of peace of mind.

Humiliation, shame and stigma

The stigma of poverty is a recurring theme. As a consequence, poor people often try to conceal their poverty to avoid humiliation and shame.

One deeply felt deprivation is not being able to do what is customary in the society. Frequently cited, for example, is not being able to entertain visitors or enjoy social life. In Malawi, there is shame from not having toilets for visitors, or money to buy a coffin for burying a relative. In Beisheke in the Kyrgyz Republic, an elderly village man says, 'In the Soviet times we had no idea what poverty was about, we were equally wealthy, and now we feel humiliated because we cannot afford to receive guests in our houses, or visit friends and relatives. It was for that reason that we could not invite you [the study team] to our house when we first met.'

Poor people sometimes feel shame and anger in accepting or having to accept alms or special treatment. In India this does not appear to apply to programmes that give poor people well-recognized rights, like the government ration shops. Similarly in Viyalagoda, Sri Lanka those who are poorer say it is a great help that their children are getting school books and uniforms: earlier their uniforms had been yellowish in colour after several washings and they were ashamed. Now their children can sit together with others without any shame. By giving books and uniforms instead of money, the government has done a great thing.

By contrast, in Novy Gorodok, Russia even the most needy are humiliated to take poor quality goods provided for them by the welfare office. One participant commented, '[The food] is spoiled, and at prices higher than in the shops. I took a sack of flour once, and there were worms.' Sexual abuse, with its physical violence as well as humiliation, is a greater threat for those in poverty, especially for women, given the places in which they live. In Dock Sud, Argentina most rapes are not reported because of shame. The same applies with sexual abuse, harassment and exploitation. In Bulgaria, a participant in a discussion group of women says, 'Only young girls aged under 20 or 22 can find a job. If they are 25 or older, nobody wants them. I can do the job of a waitress perfectly well, but the boss wanted somebody who'd do another job for him just as well.'

Poor people often experience humiliation in their encounters with officials and those delivering services. In Chittagong, Bangladesh discussion groups report that '*thana* [administrative unit between the village and district level] officials are corrupt, unaccountable "to anyone" for their dishonest acts and only show "special respect" to the rich'. Colour prejudice is mentioned in Brazil and Ecuador.

Appearances and clothes, as well as being an important part of physical well-being, are mentioned as important for self-respect and, conversely, they can be a source of shame. In Etropole, Bulgaria 'people who cannot afford warm clothes for the winter go to work. Then they come back and stay at home under a pile of blankets, shivering with cold. They don't go out. They are ashamed to meet other people. If they run into a friend and are invited for a drink they must refuse. So they would rather not go out at all.' In the Kyrgyz Republic a middle-aged woman says, 'My daughter came from school crying. Somebody at school called her a beggar, because she was wearing the jacket that we received as humanitarian aid. She refused to go to school.'

Anguish, loss and grief

Anguish, loss and grief are implicit in so many life histories of poor people, and these speak through the pages of the case studies. Sickness and death are very frequent. Anguish, when loved ones are sick and treatment is known but cannot be afforded, is found in all societies, and not only among poor people. For many participants, though, this experience is common, acute and agonizing, and for many it comes more and more often. Especially in Africa, the rising incidence of HIV/AIDS and malaria has combined with shrinking access to affordable treatment.

Psychological ill-being is marked where there has been a sharp decline in the levels of living and well-being, and where people from former middle classes have become impoverished. This is most notable among the former middle classes in Bosnia and Herzegovina, Bulgaria, the Kyrgyz Republic, Russia and Uzbekistan who are now the 'new poor'. The Bosnia and Herzegovina National Report speaks of 'psychological ill health' in all the communities. In one, the psychological effects of economic misery are listed as 'one's psychological health, distancing oneself or withdrawing from others, tensions between people, irritability, insecurity, apathy, nervousness, monotony, and dissatisfaction'.

The burden of war and civil disturbance for those caught up in them is expressed in Bosnia and Herzegovina, for example, in Bijeljina, especially by anguished women whose husbands and sons were fighting. The trauma of refugees and others who have suffered from violence is an extreme form of mental distress. Instant impoverishment often combines with fear and the anguish of loss, especially when family members are at risk or have been killed. Just how terrible the effects can be is expressed by one older woman in Bijeljina: 'I had to send a husband and two sons to the front lines and wait for them to return – or not. I did not think about eating, sleeping, dressing or anything. I would lie down and awake in tears. What have we lived to experience?' For her, spiritual poverty is more devastating than her material poverty: 'You can never recover from spiritual impoverishment.'

In the former Soviet region, participants express a profound sense of loss regarding their earlier level of living, when they had guaranteed jobs, free education and health care, social safety nets and recreation. Nostalgia is too weak a word to describe what they feel. At the same time, as with other loss and bereavement, they know it has gone forever. 'Those who don't feel sorry about the collapse of the Soviet Union have no heart, but those who think that it may be restored have no brain', says an elderly man in the Kyrgyz Republic.

Bald figures of life expectancy do not show what they mean in human terms. The horrors, separations and losses in war and civil disorder have become the commonplaces of journalism and television. The avoidable loss of loved ones in the quiet crisis of poverty is on a much larger scale, but unseen. The experience is worse when the bereaved are denied the last rites, grieving and consolation, which are customary and due in their society, because of the simple fact of their own poverty.

The ill-being of children

Parents are again and again preoccupied with securing a good life for their children. So the children's own experience and view of the bad life have a double importance: for themselves as children and for adults as their parents and guardians.

Table 7.1 *Dislikes and fears of children in Ho Chi Minh City, Vietman*

Girls	*Boys*
• Having to drop out of school, special classes closing down • My forthcoming school exams • Fighting in the community • Homeless people being cold during storms • Drug addiction in the neighbourhood • Gambling • Loan sharks • Leaking roofs in the neighbourhood • Flooding of the neighbourhood and houses • A dirty and polluted neighbourhood • That our house might collapse • Friends being too poor to afford new clothes • Neighbourhood children dropping out of school and working hard • Drunken men beating up their wives and children • Quarrelling between my mother and father • That my mother works too hard • That my family might break up • Having no money to buy rice • Having no money to pay for rent or medical treatment • Having nobody to look after me if my parents are sick • Being robbed, break-ins and theft • Having our house and neighbourhood cleared away • The rich looking down on the poor people	• Sickness of teacher, causing class to close down • Failing to move up a grade; having to repeat a class • Sniffing heroin, drug addiction, young drug addicts stealing and robbing • Gambling • Fighting and quarrelling in the community • Robbery, especially of dogs • Street accidents happening to children • Neighbourhood fires • A dirty and polluted neighbourhood • Prostitution among young people in the community • Spread of AIDS • Sickness of my family members or mother • Fights and conflict between my mother and father • Divorce of my parents; family splitting up • My mother running off with another man • Sale of our house to repay a debt • Having our house demolished and cleared away • Having a roof that leaks • Having no house of our own; having to share a room with other families • Having no money • Being unable to get a job • Rich people scolding the poor people they hire • Richer families not allowing us to watch their TV • Rich people living in luxury, not helping poor people • Richer people looking down at us

In Ho Chi Minh City, Vietnamese children summarize their feelings about the consequences of being poor as deprivation and resentment (see Table 7.1). They resent that they cannot go to school or to the school they want, and that their parents have neither the time nor the money to take them on outings. Boys and girls over ten resent being scolded because of indebtedness and the failure to repay loans. The boys say that everyone in the family is working, but there is still not enough to eat; that they have to accept beatings from others and can do nothing in return; and that they are always blamed when something is stolen. Boys under ten cannot have a birthday party like other children. Girls under ten are teased by richer children because they are poor. And girls over ten resent having to agree with richer people and act as their inferiors, even if what they [the rich people] say is wrong.

The vivid directness of what girls and boys see and experience as the bad life is revealing. The Ho Chi Minh City report concludes that 'what the young emphasize more than any other group … is the effect of poverty on the family itself. They see poor families as tense, conflictual and subject to break-down.' It is perhaps no surprise that family harmony matters much to children, but worthy of note that they see a link between poverty and bad relations in the family. Also, both girls and boys mention the behaviour of the rich, and being looked on badly and being treated badly by them – something that adults, perhaps through prudence, mention only occasionally.

For their part, the parents' pain when they cannot provide for and look after their children is shown to be a big part of adult ill-being.

In Muynak, Uzbekistan in the extreme of distress, there is an ultimate way out: 'There are families who do not eat and drink in three days. People die of hunger. For example, Ayagan was a good guy. He could not provide his family with food, his children cried and then he shot himself.'

Reflections

In understanding what a good experience of life is, there is perhaps no end, no final answer. But if development is to enhance the well-being of poor people in their own terms, there is much to reflect on in what they say.

The discussions in Ethiopia generated the list of dire statements in Box 7.3. Yet one of the team leaders in Ethiopia, on approaching a very poor, remote community, heard singing and dancing. This can jolt us into recognizing that there are many good things, each in its own culture, which contribute to well-being: not only singing, dancing and music, but also festivals, ceremonies and celebrations; good things in their seasons; love, kindness and sacrifice; and religious and spiritual practices and experiences. But to many of those who are most deprived, these fulfillments are diminished or denied.

The overarching questions are then whether, where and why human well-being is being enhanced or eroded; whether for many millions the singing and dancing are dying or renewing; whether the conditions for material, bodily, social, mental and spiritual well-being are improving or getting worse; and above all how to enable poor people to gain for themselves more of the good life to which they aspire.

8

Who Will Feed China?

L. Brown

Overview: The Wake-up Call

We often hear that the entire world cannot reasonably aspire to the US standard of living or that we cannot keep adding 90 million people a year indefinitely. Most people accept these propositions. Intuitively, they realize that there are constraints, that expanding human demand will eventually collide with the Earth's natural limits.

Yet, little is said about what will actually limit the growth in human demands. Increasingly, it looks as though our ability to expand food production fast enough will be one of the earlier constraints to emerge. This is most immediately evident with oceanic fisheries, nearly all of which are being pushed to the limit and beyond by human demand. Water scarcity is now holding back growth in food production on every continent. Agronomic limits on the capacity of available crop varieties to use additional fertilizer effectively are also slowing growth in food production.

Against this backdrop, China may soon emerge as an importer of massive quantities of grain – quantities so large that they could trigger unprecedented rises in world food prices. If it does, everyone will feel the effect, whether at supermarket checkout counters or in village markets. Price rises, already under way for seafood, will spread to rice, where production is constrained by the scarcity of water as well as land, and then to wheat and other food staples. For the first time in history, the environmental collision between expanding human demand for food and some of the Earth's natural limits will have an economic effect that will be felt around the world.

It will be tempting to blame China for the likely rise in food prices, because its demand for food is exceeding the carrying capacity of its land and water resources, putting excessive demand on exportable supplies from countries that are living within their carrying capacities. But China is only one of scores of countries in this situation. It just happens to be the largest and, by an accident of history, the one that tips the world balance from surplus to scarcity.

Analysts of the world food supply/demand balance have recognized that the demand for food in China would climb dramatically as industrialization accelerated

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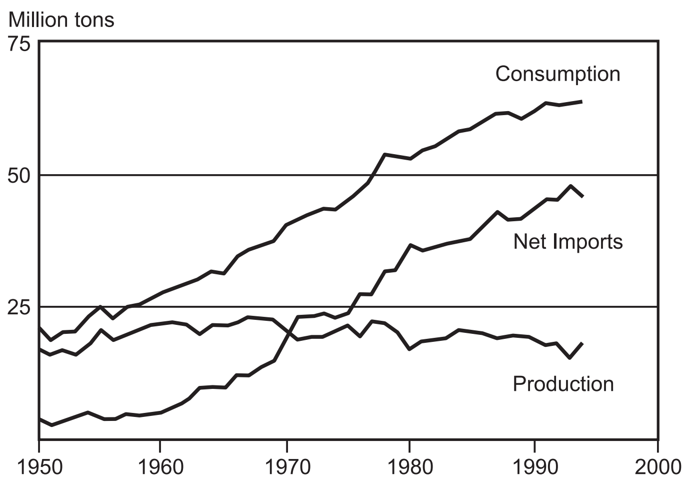
and incomes rose. They have also assumed that rapid growth in food production in China would continue indefinitely. But on this latter front, a closer look at what happens when a country is already densely populated before it industrializes leads to a very different conclusion. In this situation, rapid industrialization inevitably leads to a heavy loss of cropland, which can override any rises in land productivity and lead to an absolute decline in food production.

Historically, there appear to be only three other countries that were densely populated in agronomic terms before industrializing – Japan, South Korea and Taiwan. The common experience of these three gives a sense of what to expect as industrialization proceeds in China. For instance, the conversion of grainland to other uses, combined with a decline in multiple cropping in these countries over the last few decades, has cost Japan 52 per cent of its grain harvested area, South Korea 46 per cent and Taiwan 42 per cent.[1]

As cropland losses accelerated, they soon exceeded rises in land productivity, leading to steady declines in output. In Japan, grain production has fallen 32 per cent from its peak in 1960. For both South Korea and Taiwan, output has dropped 24 per cent since 1977, the year when, by coincidence, production peaked in both countries. If China's rapid industrialization continues, it can expect a similar decline.[2]

While production was falling, rising affluence was driving up the overall demand for grain. As a result, by 1994, the three countries were collectively importing 71 per cent of their grain. (See Figure 8.1.)[3]

Exactly the same forces are at work in China as its transformation from an agricultural to an industrial society progresses at a breakneck pace. Its 1990 area of grainland per person of 0.08ha is the same as that of Japan in 1950, making China one of the world's most densely populated countries in agronomic terms. If China is



Source: See endnote 3.

Figure 8.1 *Combined grain production, consumption and trade for Japan, South Korea and Taiwan, 1950–1994* to avoid the decline in production that occurred in Japan, it must either be more effective in protecting its cropland (which will not be easy, given Japan's outstanding record) or it must raise grain yield per hectare faster during the next few decades than Japan has in the last few – an equally daunting task, considering the Japanese performance and the fact that China's current yields are already quite high by international standards.[4]

Building the thousands of factories, warehouses and access roads that are an integral part of the industrialization process means sacrificing cropland. The modernization of transportation also takes land. Cars and trucks – with sales of 1.3 million in 1992 expected to approach 3 million a year by the decade's end – will claim a vast area of cropland for roads and parking lots. The combination of continually expanding population and a shrinking cropland base will further reduce the already small area of cropland per person.[5]

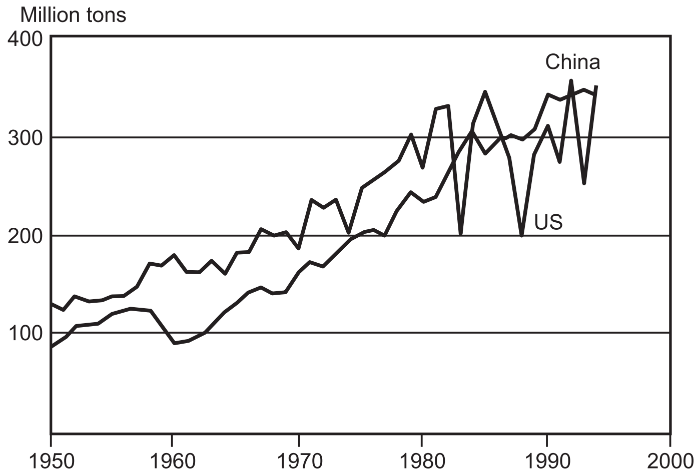
At issue is how much cropland will be lost and how fast. Rapid industrialization is already taking a toll, as grain area has dropped from 90.8 million hectares in 1990 to an estimated 85.7 million in 1994. This annual drop of 1.26 million hectares, or 1.4 per cent – remarkably similar to the loss rates of China's three smaller neighbours in their industrialization heyday – is likely to endure as long as rapid economic growth continues.[6]

China faces another threat to its food production that its three smaller neighbours did not. Along with the continuing disappearance of farmland, it is also confronted by an extensive diversion of irrigation water to non-farm uses – an acute concern in a country where half the cropland is irrigated and nearly four-fifths of the grain harvest comes from irrigated land. With large areas of north China now experiencing water deficits, existing demand is being met partly by depleting aquifers. Satisfying much of the growing urban and industrial demand for water in the arid northern half of the country will depend on diversions from irrigation.[7]

That China's grain production might fall in absolute terms comes as a surprise to many. This is not the result of agricultural failure but of industrial success. Indeed, China's record in agriculture is an exceptional one. Between 1950 and 1994, grain production increased nearly fourfold – a phenomenal achievement. After the agricultural reforms in 1978, output climbed in six years from scarcely 200 million tons to 300 million tons. With this surge, China moved ahead of the US to become the world's leading grain producer. (See Figure 8.2.)[8]

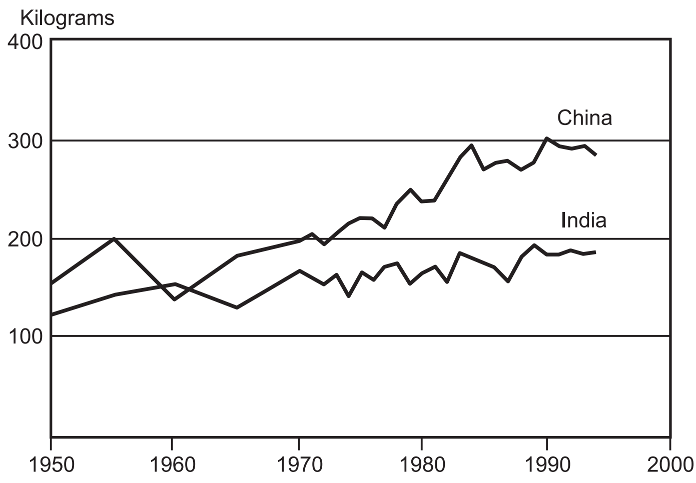
Another way of evaluating China's agricultural record is to compare it with that of India, the world's second most populous country. Per capita grain production in China, which was already somewhat higher than in India, climbed sharply after agricultural reforms were launched in 1978, opening an impressive margin over its Asian neighbor. (See Figure 8.3.)[9]

Between 1978 and 1984, China did what many analysts thought was impossible: in just six years, it raised annual grain production from roughly 200kg per person to nearly 300kg. At 200kg, almost all grain is needed to maintain a minimal level of physical activity; an additional 100kg a year opens the way for convert-



Source: See endnote 8.

Figure 8.2 *Grain production, US and China, 1950–1994*



Source: See endnote 9.

Figure 8.3 *Grain production per person, China and India, 1950–1994*

ing some grain into pork, poultry and eggs. The immediate challenge facing China is not averting starvation, for it has established a wide margin between its current consumption level of 300kg and the subsistence level. Rather, the challenge is to maintain price stability in the face of soaring demand for food, driven by unprecedented advances in income.[10]

While China's food production capacity is starting to erode as a result of its breathtaking pace of industrialization, its demand for food is surging. The country is projected to add 490 million people between 1990 and 2030, swelling its population to 1.6 billion – the equivalent of adding four Japans. Because China's population is so large, even a slow rate of growth means huge absolute increases. Yet these increases are only the beginning of the story.[11]

Even as population expands, incomes are rising at an unprecedented rate. Economic growth of 13 per cent in 1992 and again in 1993, of 11 per cent in 1994, and of an estimated 10 per cent in 1995 adds up to a phenomenal 56 per cent expansion of the Chinese economy in just four years. Never before have incomes for so many people risen so quickly.[12]

This rapid economic expansion promises to push demand for food up at a record rate. When Western Europe, North America and Japan began establishing modern consumer economies after World War II, they were home to some 340 million, 190 million and 100 million people, respectively. By contrast, China is entering the same stage with a population of 1.2 billion and an economy that is expanding twice as fast. If its rapid economic growth continues, China could within the next decade overtake the US as the world's largest economy.[13]

Past experience has not prepared us well for assessing the scale of China's future food demand. Multiplying 1.2 billion times anything is a lot. Two more beers per person in China would take the entire Norwegian grain harvest. And if the Chinese were to consume seafood at the same rate as the Japanese do, China would need the annual world fish catch.

As incomes rise, one of the first things that low-income people do is diversify their diets, shifting from a monotonous fare in which a starchy staple, such as rice, supplies 70 per cent or more of calories to one that includes meat, milk and eggs. As consumption of pork, beef, poultry, eggs, milk and other livestock products increases along with income, grain requirements rise rapidly.[14]

In neighbouring Japan, the soaring demand for grain driven by prosperity combined with the heavy loss of cropland since mid-century pushed dependence on grain imports to 72 per cent of total grain consumption in 1994. These same forces are now at work in China. It is one thing for a nation of 120 million people to turn to the world market for most of its grain. But if a nation of 1.2 billion moves in this direction, it will quickly overwhelm the export capacity of the US and other countries, driving food prices upward everywhere.[15]

The first signs of a growing imbalance between the demand and supply for grain in China became evident in early 1994. In February, grain prices in China's 35 major cities had jumped 41 per cent over the same month in 1993. In March, driven by panic buying and hoarding, the rise continued unabated. In response, the government released 2.5 million tons of grain from stocks to check the runaway increase in prices. This calmed food markets, but only temporarily. By October, grain prices were 60 per cent higher than a year earlier. More grain reserves were released, and the government banned trading in rice futures on the Shanghai Commodity Exchange. Speculators were driving futures prices upward, leading to panic among urban consumers. The 1994 inflation rate of 24 per cent – the worst since modern China was created in 1949 – was largely the result of rising food prices.[16]

Resisting the import of grain throughout most of 1994, Beijing let prices rise as much as possible to encourage farmers to stay on the land. In recent years an estimated 120 million people, mostly from the interior provinces, have left the land and moved to cities in search of high-paying jobs. This rootless, floating population, roughly the size of Japan's, wants to be part of the economic revolution. As a potential source of political instability, these migrants are a matter of deep concern in Beijing. The government is trying to maintain a delicate balance, letting the price of grain rise enough to keep farmers on the land but not so much that it creates urban unrest that could lead to political upheaval.[17]

Leaders in Beijing are also trying to deal with massive unemployment and underemployment, with much of the latter masked by villagers eking out a meager existence on tiny plots of marginal land. Creating enough jobs to employ productively an estimated 800 million workers depends on maintaining double-digit or near double-digit rates of economic growth. The government opened the country up to foreign investment in part because it was the only way to get the capital and technology needed to achieve this vital goal.[18]

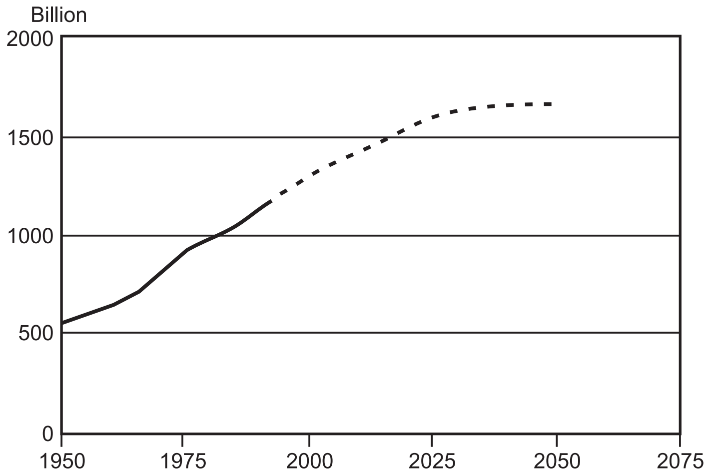
If China holds together as a country and if its rapid modernization continues, it will almost certainly follow the pattern of Japan, South Korea and Taiwan, importing more and more grain. Its import needs may soon far exceed the exportable supply of grain at recent prices, converting the world grain economy from a buyer's market to a seller's market. Instead of exporters competing for markets that never seem large enough, which has been the case for most of the last half-century, importers will be fighting for supplies of grain that never seem adequate.[19]

In an integrated world economy, China's rising food prices will become the world's rising food prices. China's land scarcity will become everyone's land scarcity. And water scarcity in China will affect the entire world.

In short, China's emergence as a massive grain importer will be the wake-up call that will signal trouble in the relationship between ourselves, now numbering 5.7 billion, and the natural systems and resources on which we depend. It may well force a redefinition of security, a recognition that food scarcity and the associated economic instability are far greater threats to security than military aggression is. The chapters that follow analyse this transformation, explaining why and how it is likely to come about.[20]

Another Half-billion

As Chinese leaders analysed future population, land and water trends some 20 years ago, they realized that they had to choose between the reproductive rights of the current generation and the survival rights of the next generation. What separates the government in Beijing from those in many other countries is that it is desperately trying to protect the options of the next generation, politically difficult



Source: See endnote 21.

Figure 8.4 *Population of China, 1950–94, with projections to 2050*

though that may be. This farsightedness and the political courage of the government of China deserve recognition.

In 1982, China's population reached 1 billion, making it the first member of an exclusive club. By 2017, its population is projected to reach 1.5 billion – equal to the world's entire population in 1900. Its demographic growth is then expected to slow and its population to peak at 1.66 billion in 2045, after which it should start to decline slowly. (See Figure 8.4.)[21]

Looked at in terms of the last four decades and the next four, the magnitude of China's population growth becomes clear. From 1950 to 1990, China added 571 million people. From 1990 to 2030, it is projected to add 490 million more. This anticipated addition reflects an impressive slowing in the rate of population growth, but it is still nearly a half-billion people. Stated otherwise, during the next four decades China will be adding an average of roughly 12 million people to the world annually.[22]

Many people think of Asia and Europe as having similar population densities, but in reality Asia has many more people per hectare of grainland than Europe does. The grainland per person in China today is roughly half that in France and it is inherently less fertile. The other difference is that Europe's population has stopped growing. Now that the growth in grain use per person that accompanied rising incomes has also come to an end, the demands made by the region's population on its land and water resources have stabilized. Europe is living well within its food production capability or, in ecological terms, its food carrying capacity. Indeed, it is producing a modest grain surplus.[23]

In geographic area, China and the US are essentially the same size. The big difference is that the western half of China is largely inhospitable to human habitation. Lacking basic life-supporting soil and water resources, it contains only a small percentage of the country's people.

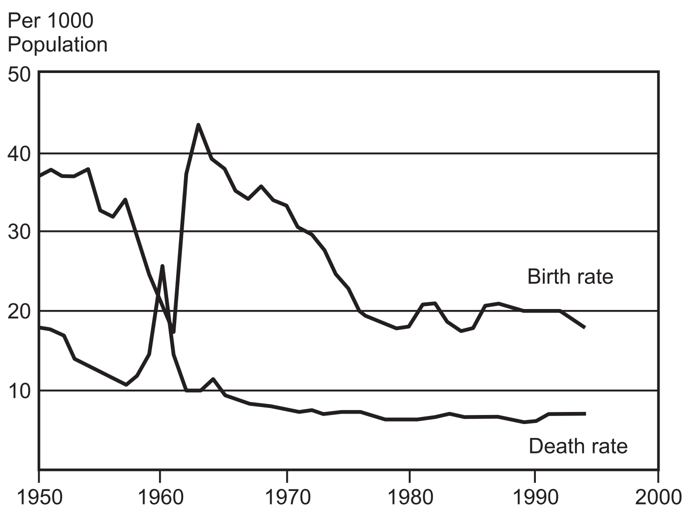
For China, where the opportunity for bringing new land under cultivation is limited by water scarcity, population growth has a double-edged effect. First, it is shrinking the cropland area per person, as a fixed area is divided among an ever larger number of people. At the same time, the new citizens bring demands for living space, which in turn generates pressure to convert cropland to residential purposes. Simply housing an additional 490 million people in the next 40 years will require an enormous area, some of which will be cropland.[24]

There is a certain fascination with the demographic trends and issues of China partly because of its sheer size. In addition, the chaos of the Great Leap Forward and the arithmetic of the resulting famine that was long concealed from the outside world have intensified interest in China's demographic history.

In the late 1950s, during the Great Leap Forward, millions of farmers were diverted to large construction projects, including roads, huge earthen dams and backyard steel furnaces. This movement of labour from agriculture led to massive food shortages. Official records now show that 30 million Chinese starved to death during 1959–1961. The demographic effect of the famine, however, extended far beyond these deaths.[25]

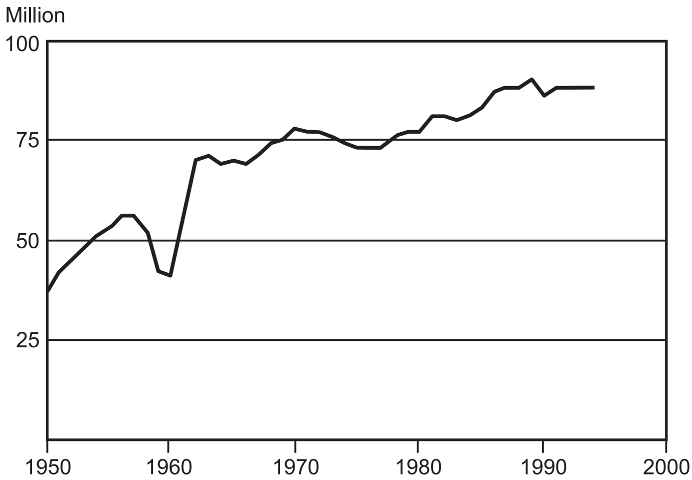
In populations that are near starvation, the frequency of intercourse decreases, sharply reducing the number of possible pregnancies. Beyond this, severely malnourished women cease ovulating, thus further reducing the number of pregnancies. Women who do conceive when they are severely malnourished often miscarry.[26]

During the heart of the famine in 1960, the number of deaths in China actually exceeded the number of births. The birth rate fell to 21 per 1000 population



Source: See endnote 27.

Figure 8.5 *Crude birth and death rates in China, 1950–1994*



Source: See endnote 28.

Figure 8.6 *Annual addition to world population, 1950–1994*

while the death rate climbed to 25 per 1000, leading to a decline in China's population for one year. (See Figure 8.5.)[27]

The drop was so steep that it markedly affected the number of people added to world population. (See Figure 8.6.) Between 1950 and 1957, that number was increasing steadily, climbing from 39 million to 57 million. It then began to drop, reaching a low of 41 million in 1960. As China recovered from the famine, the annual addition climbed sharply to 70 million in 1962, recovering the trend that had existed before the famine.[28]

The Great Famine of 1959–1961 left an indelible imprint on China's national psyche. John Bermingham, president of the Colorado Population Coalition, observes that 'just as an American generation was seared by the Great Depression and a German generation by runaway inflation, the Chinese have had a generation seared by famine'. These analogies help us understand the effect of the Chinese famine, but the latter was more traumatic simply because it was life-threatening for such a vast number of people.[29]

Like many governments, China was slow to recognize the population threat. Socialist ideology made it easy to dismiss the problem. As demographer Michael Teitelbaum notes, 'For Marx, the fact that people were producers as well as consumers meant that the resource limits emphasized by the classical economists could arise under capitalism, but not under socialism.'[30]

A quarter-century after the communist takeover in 1949, the government began to recognize population growth as a matter of concern. This occurred as part of the post-Mao reassessment in which projections of China's population growth were made. Much to the dismay of officials, based on an assumption of two children per couple, China could expect to add the better part of 1 billion people, adding the equivalent of an India to its existing population.[31]

As analysts attempted to calculate the consequences of population increase for cropland and water supply per person, and the availability of capital for creation of jobs, they realized that this was not a viable proposition. They were then confronted with one of the most politically difficult challenges for any government: the need to shift to a one-child family.

China faces some unique and difficult demographic issues. In contrast to Europe, there is no meaningful emigration safety valve. For countries such as England, Ireland, Germany, Italy and Spain, mounting population pressure during their early development translated into a steady flow of migrants, many of them bound for the New World. Today, there are more people of Irish extraction in the US than in Ireland. Similarly, there are more Spanish descendants in Latin America than in Spain. Indeed, the New World is populated largely with the demographic overflow of Europe.[32]

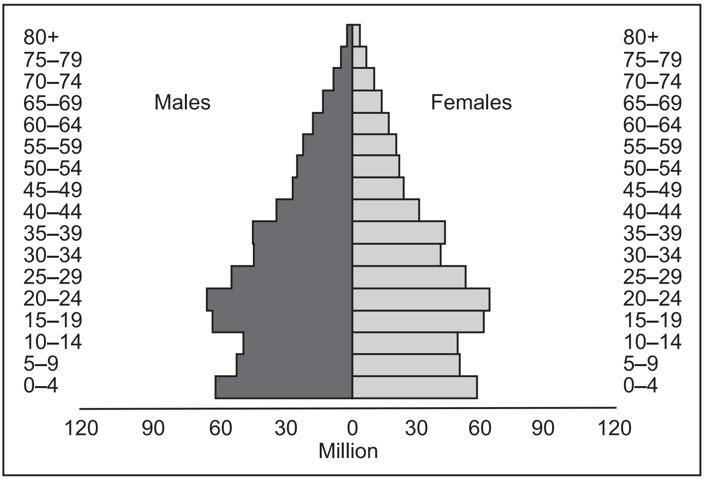
The mounting population pressures in China today are occurring in a world far different from that of a century or two ago. No sparsely settled, habitable areas still exist. No country or group of countries wants to entertain the idea of absorbing 12 million Chinese each year.

Trying to put the brakes on population growth in China has not been easy. The government in Beijing, like those in many other developing countries, waited too long before implementing a meaningful effort to reduce family size. Faced with a trade-off between smaller families in the present or deteriorating living conditions in the future as population pressures mounted, Chinese leaders opted in 1979 for the one couple/one child policy.

This policy, which explicitly reflects the interests of future generations, has run into heavy resistance. One source of difficulty has been a strong preference for male children, a desire so powerful, particularly in rural areas, that it has led to widespread female infanticide. In each annual cohort, males outnumber females until age 64; thereafter, females outnumber males. The conflict between local officials trying to implement this policy and couples intent on having more than one child has led, not surprisingly, to charges of coercion. It illustrates all too well the political conflicts that can develop within a society that is overrunning its human carrying capacity.[33]

Implementing the one-child-family policy has become more difficult in recent years. Job seekers migrating from countryside to city can more easily evade official monitoring of family size. Some families are becoming so affluent that they can readily pay the stiff penalty for having additional children. Moving quickly from a situation of rapid population growth to one of population stability has proved to be politically challenging to say the least.[34]

Nevertheless, it is possible to consider a scenario that would stabilize population size in China well below the 1.66 billion peak projected for 2045. The 1990 population pyramid, which gives the size of various age groups in the population, shows two age groups that are unusually small. (See Figure 8.7.) The first group, those who are 30–34 years of age, was reduced by the famine of 1959–1961. The second, smaller group – those 10–14 years of age – shows the effect of family plan-



Source: See endnote 35.

Figure 8.7 *Age pyramid of China's population, 1990*

ning programmes adopted in the mid-1970s and the echo effect of the smaller numbers born during the famine reaching reproductive age. If China can sustain its one-child-family programme when the people born between 1975 and 1986 reach childbearing age, its population size could stabilize sooner rather than later, and far short of the projected 1.66 billion.[35]

In 1993, the Population Reference Bureau (PRB) pointed out that China had succeeded in lowering its fertility below replacement level – that is, the total number of children per woman was 2 or fewer. This was achieved within two decades of launching family planning programmes.[36]

Carl Haub, senior demographer at PRB, noted that the birth rate was 21.1 per 1000 population in 1990 and that it dropped to 19.7 in 1991 and to 18.2 in 1992. Since then the decline has continued, reaching 17.7 in 1994. This reduced China's population growth rate to 1.1 per cent, roughly the same as that of the US. The drop in China's population growth rate from 2.7 per cent in 1970 to 1.1 per cent in 1994 has played a key role in lowering the global population growth rate during that time from 2.1 per cent to 1.6 per cent.[37]

Recognizing the urgency of stabilizing population size, China's President and Communist Party chief, Jiang Zemin, renewed the call for one couple/one child in March 1995. Concern with the environmental, economic and social effects of continuing population growth in China runs deep. President Jiang pointed out that 'the rapid increase in a big population base has a direct bearing on the problems of food, of jobs, of education, of resource destruction, of environmental protection and an imbalanced ecology.' Increasingly, Chinese leaders are becoming aware of the environmental consequences of the combined effect of population growth and rising affluence that their country is experiencing.[38]

Notes

Overview: The Wake-up Call

1 US Department of Agriculture (USDA), Economic Research Service (ERS), 'Production, Supply, and Demand View' (electronic database), Washington DC, November 1994.
2 Ibid.
3 Figure 8.1 from ibid., with 1950–1959 figures from USDA, ERS, 'World Grain Database' (unpublished printout), Washington DC, April 1989.
4 USDA, op. cit. note 1; USDA, op. cit. note 3; US Bureau of the Census, as published in Francis Urban and Ray Nightingale, *World Population by Country and Region, 1950–90 and Projections to 2050* (Washington DC: USDA, ERS, 1993).
5 Patrick E. Tyler, 'China Planning People's Car to Put Masses Behind Wheel', *New York Times*, 22 September 1994; Nicholas D. Kristof and Sheryl WuDunn, China Wakes (New York: Random House, 1994).
6 USDA, op. cit. note 1, with updates from USDA, ERS, 'World Agriculture Production', Washington DC, March 1995.
7 Irrigated area from USDA, ERS, 'China Situation and Outlook Series', Washington DC, July 1993, and from UN Food and Agriculture Organization (FAO), *Production Yearbooks* (Rome: various years); Professor Xu Zhifang, President, Chinese National Committee on Irrigation and Drainage, speech for the World Water Council-Interim Founding Committee, Montreal Canada, 31 March 1995.
8 Figure 8.2 from USDA, op. cit. note 1, and from USDA, op. cit. note 3.
9 Figure 8.3 from USDA, op. cit. note 1, from USDA, op. cit. note 3, and from Bureau of the Census, op. cit. note 4.
10 Per capita figures from USDA, op. cit. note 1, and Bureau of the Census, op. cit. note 4.
11 Bureau of the Census, op. cit. note 4; population of Beijing from United Nations, *Estimates and Projections of Urban, Rural, and City Populations 1950–2025: The 1982 Assessment* (New York: 1985).
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16 Sheila Tefft, 'A Shrinking Rice Bowl in China: Rising Food Prices Spur Unease', *Christian Science Monitor*, 19 January 1995; Gao Anming, 'Experts Note Reasons for Hikes in Grain Prices', *China Daily*, 6 January 1995; Martin Wolf, 'Zooming in on the Threat of Inflation', *Financial Times*, 7 November 1994; 'China to Buy More Wheat, Corn From US, Traders Say', *Journal of Commerce*, 19 January 1995; 'China Restricts Trading in Shanghai Rice Futures', *Journal of Commerce*, 26 October 1994; Joseph Kahn, 'China Fails to Curb Its Runaway Growth', *Wall Street Journal*, 3 January 1995.
17 World Bank, *China: Strategies for Reducing Poverty in the 1990s* (Washington DC: 1992).
18 Peter Hannam, 'China Seen Facing Choice: Inflation or Unemployment', *Journal of Commerce*, 27 September 1994.
19 USDA, 'Grain: World Markets and Trade', Washington DC, various issues.
20 Population Reference Bureau, *1994 World Population Data Sheet* (Washington DC: 1994).

Another Half-billion

21 Figure 8.4 from US Bureau of the Census, as published in Francis Urban and Ray Nightingale, *World Population by Country and Region, 1950–90 and Projections to 2050* (Washington DC: US Department of Agriculture (USDA), Economic Research Service (ERS), 1993); 1900 world population from United Nations, *The Future Growth of World Population* (Rome: 1958).

22 Bureau of the Census, op. cit. note 21.

23 Grainland per capita calculated with population from Bureau of the Census, op. cit. note 21, and grain area from USDA, ERS, 'Production, Supply, and Demand View' (electronic database), Washington DC, November 1994; grain trade data from ibid.

24 Population from Bureau of the Census, op. cit, note 21.

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27 Figure 8.5 from United Nations, *Monthly Bulletin of Statistics*, February 1994.

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34 Mufson, op. cit. note 33.

35 Population projection from Bureau of the Census, op. cit. note 21; Figure 8.7 from Zha and Qiao, op. cit. note 33.

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9

Introduction to Ecoagriculture

J. McNeely and S. Scherr

The Challenge: Agricultural Intensification, Rural Poverty and Biodiversity

Many ecologists fear that the world is poised on the brink of the largest wave of wild species extinctions since the dinosaurs disappeared 65 million years ago. If current trends continue, we could lose or greatly reduce populations of 25 per cent of the world's species by the middle of this century. Since global awareness of this crisis emerged in the late 1970s, conservationists have focused on protecting endangered species and endangered habitats primarily through the establishment of protected areas. Nearly 10 per cent of the Earth's land is now officially protected, and land purchases to create private reserves are expanding such areas. Agricultural production areas, by contrast, have been largely ignored by conservationists. These areas were assumed to have habitat conditions so radically modified from their original state that their potential contribution to biodiversity conservation could only be marginal. Permanent croplands were estimated in the early 1980s to account for only 12 per cent of global land area, so conservation efforts were understandably focused elsewhere (apart from widespread efforts to limit farmland conversion).

Part I [of *Ecoagriculture*] draws on new global data to argue that in this new century food and fibre production – both that produced by agriculture (domesticated crops, livestock, trees and fish) and harvested from natural systems (forests, grasslands and fisheries) has come to be the dominant influence on rural habitats outside the arctic, boreal, high mountain and desert ecoregions. Growing human populations, increasing demand for food and fibre products, and growing concern about rural poverty mean that agricultural output must necessarily expand for at least several more decades until the rate of human population growth begins to stabilize, or even begins to decline (as it already has in some eastern European countries). Adequate growth in supply is by no means assured, especially in areas where productivity is limited by poor soils, difficult climates and insufficient water.

Indeed, the World Bank says that billions of people are at risk of serious food insecurity and deepening poverty.

Future economic development in the poorest and most biodiversity-rich countries will depend heavily on agriculture and natural resource management that continue to enhance productivity and adapt to changing conditions. Agriculture will remain economically and socially important. Even industrialized countries cannot reasonably expect to save biodiversity at the expense of agricultural output and incomes, much less the developing countries of the tropics. Rather, the challenge is to conserve biodiversity while maintaining or increasing agricultural production. Protected areas will remain a critical element of any conservation strategy, but this book [*Ecoagriculture*] stresses that it is essential to focus greater conservation effort on the large areas under agricultural use.

During the 20th century we humans witnessed momentous economic, social and technological changes. New technologies such as automobiles, airplanes, container ships, telephones and computers profoundly affected our way of life, enabling us to escape reliance on local ecosystems and become part of a global economy. Radio, movies and television transformed the way we related to one another and to the world. Public health systems and education became much more widespread, and material wealth – even in the poorest of countries – reached levels inconceivable at the beginning of the century. Our population more than quadrupled, from 1.4 billion in 1900 to more than 6 billion in 2000. As a species, we had a very good century in many ways.

Our 20th-century prosperity was fuelled in part by a constantly growing supply of food, enabling us not only to feed a rapidly growing population, but also to amass food surpluses on a scale never before reached. Based on improved seeds, widespread use of agricultural chemicals, modern farm machinery and better transportation systems, agricultural production soared. In the past decade alone, production of cereal crops increased by 17 per cent, roots and tubers by 13 per cent, meat by 46 per cent and marine fish by 17 per cent (World Resources Institute, 2002). With such impressive gains on so many fronts, why should we worry about the 21st century?

First, although more people are consuming more food than ever before, inequity is increasing as well: some parts of the world suffer from growing overconsumption while others go hungry. The World Bank estimates that some 800 million people remain undernourished, in large part because they cannot access the food that is produced. That number is likely to grow because the world's population increases by 75–85 million people each year. Some experts suggest that in 30 years we will need at least 50–60 per cent more food than we produce now, in order to meet global food demand and enjoy at least a modest degree of greater affluence. If that food is to be accessible to the rural poor, then much of it must be produced where they live, and in ways that increase both their consumption and income. Yet food-producing systems throughout the world are already stressed by eroding soils, declining freshwater reserves, declining fish populations, deforestation, desertification, natural disasters and global climate change. These and various other factors are making it increasingly difficult to maintain, much less increase, food production in many areas of the world.

What is more, the impressive gains for our species have often come at the expense of other species with whom we share our planet. The main victim of our affluence has been wild biodiversity – the non-domesticated portion of our planet's wealth of genes, species and ecosystems. Agricultural production has converted highly diverse natural ecosystems into greatly oversimplified ecosystems, led to pollution of soils and waterways, and hastened the spread of invasive alien species. According to Heywood and Watson (1995), 'over-whelming evidence leads to the conclusion that modern commercial agriculture has had a direct negative impact on biodiversity at all levels: ecosystem, species, and genetic; and on natural and domestic diversity'.

While major investments continue to improve agricultural productivity in centres of surplus commercial production, the needs of the rural poor tend to be ignored. As a result, the poor struggle to survive, managing their resources to meet immediate needs rather than invest in a more secure future. Many of these poor people live in areas remote from modern agricultural development but close to habitats supporting the greatest wild biodiversity. Often they have little choice but to exploit these habitats for survival.

Without urgent action to develop the right kind of agriculture, wild biodiversity will be further threatened. The resulting destruction of natural habitats will deprive both local people and the global community of important benefits such as food, fodder, fuel, construction materials, medicines and genetic resources, as well as services such as watershed protection, clean air and water, protection against floods and storms, soil formation and even human inspiration.

These threats to biodiversity pose a major dilemma for modern society. On the one hand, modern intensive agriculture has made it possible for the expanding human population to eat more food. On the other hand, agriculture is now spreading into the remotest parts of the world, often in destructive forms that further reduce wild biodiversity and undermine the sustainability of the global food production system. At the same time, reducing biodiversity and simplifying ecosystems can undermine local livelihoods by destabilizing ecosystem services. Recent mud slides in several Latin American countries, floods in Bangladesh and droughts in southern Africa are all 'natural' phenomena made into a disaster for local people due at least in part to loss of biodiversity.

This situation has led many in the environmental community and the general public to promote the establishment of protected areas where human use – in particular agricultural use – is supposed to be greatly restricted. While such management measures clearly are needed to preserve many types of wild biodiversity, they face many challenges. Some centres of the greatest or most valued wild biodiversity are being surrounded by areas of intensive agricultural production and high rural population densities. In some areas, large human populations preclude the establishment of extensive reserves, so the protected areas tend to be too small to support viable populations of the species they are designed to protect. In these human-dominated ecosystems, conservation action in isolated protected areas is doomed to fail, unless fundamental changes also take place in the adjacent agricultural landscape. Moreover, some types of wild biodiversity, such as some species of birds and butterflies, actually thrive best in farmed and populated landscapes. Farming is a practice that extends at least 10,000 years back into human history, and many species of plants and animals have evolved in concert with the development of agriculture. Some species of large mammals (especially wild cattle in Asia) may even depend on shifting cultivation (Wharton, 1968).

Aggressive efforts to conserve wild biodiversity have sometimes reduced the livelihood security of rural people, especially the poor in developing countries (Pimbert and Toledo, 1994). But this need not be the case (McNeely, 1999). Rural populations historically have established conservation practices to protect environmental services important to their own food production, water supply and spiritual values (see, for example, Western and Wright, 1994; Singh et al, 2000). Examples show that managing biodiversity through a combination of conservation measures and improved and diversified agricultural systems can increase incomes and household nutrition, reduce livelihood risks and provide collateral benefits such as increased freshwater reserves and fewer mud slides after heavy rains.

Thus new models for biodiversity conservation need to be developed, involving effective links among the fields of farmers, the pastures of ranchers, the managed forests of foresters and the protected areas managed especially for wild biodiversity. Conservation options are available besides just 'locking away' resources on which the poor depend for their survival and assets that low-income countries could use to promote development and national food security. Agricultural landscapes can be designed more creatively to take the needs of local people into account while pursuing biodiversity objectives.

Ecoagriculture

A central challenge of the 21st century, then, is to achieve biodiversity conservation and agricultural production goals at the same time – and, in many cases, in the same space. In this book [*Ecoagriculture*] the management of landscapes for both the production of food and the conservation of ecosystem services, in particular wild biodiversity, is referred to as *ecoagriculture*. For a start, improved natural resource management and technological breakthroughs in agriculture and resource use is essential to enhance our ability to manage biodiversity well. Genetic improvements in the major agricultural crops that feed the world will continue to be essential for maintaining and increasing productivity. But a much wider range of genetic, technological, environmental management and policy innovations must be developed to support wild biodiversity in the world's bread baskets and rice bowls as well as in the extensive areas where food production is more difficult.

Diverse approaches to make agriculture more sustainable, while also more productive, are flowering around the world; many of these reduce the negative effects of farming on wild species and habitats. Such approaches need to be integrated more intentionally with conservation objectives, particularly in biodiversity 'hotspots' (Myers, 1988) and areas where the livelihood of the poor depends on ecosystem rehabilitation. New approaches to agricultural production must be developed that complement natural environments, enhance ecosystem functions and improve rural livelihoods. While trade-offs between agricultural productivity and biodiversity conservation often seem stark, some surprising and exciting opportunities exist for complementarity. Local farmers and institutions, such as universities and agricultural research centres, are leading the way through active experimentation and adaptation of existing knowledge. But more targeted research on ecoagriculture is needed, and such research must be considered a global priority if major advances are to occur. Environmental and agricultural researchers must learn to work closely together to resolve existing conflicts between natural biodiversity and agricultural production in different ecoregions and under different management systems.

This book examines some of the current linkages between wild biodiversity and agriculture. It suggests strategies for improving agriculture while maintaining or enhancing wild biodiversity, assesses dozens of systems where this is already being done and describes how research and policy action can contribute to conserving wild biodiversity. The book is structured in three parts. The first part describes the challenge of reconciling conservation and agricultural goals in areas important for both. The second part discusses the ecoagriculture approach and presents diverse case studies illustrating key strategies. The third part explores how policies, markets and institutions can be reshaped to support ecoagriculture in areas that are hotspots for both biodiversity and food security.

The emphasis here is on tropical regions of the developing world, where increased agricultural productivity is most vital for food security, poverty reduction and sustainable development, and where so much of the world's wild biodiversity is threatened. But the book also highlights lessons learned in developed countries (for example, California Wilderness Coalition, 2002) where these are of wider relevance. While profitable ecoagriculture systems can and must be developed for large-scale commercial farming enterprises that are operating in areas of threatened biodiversity, most examples in this book emphasize strategies for small-scale, low-income farmers involved in commercial or subsistence production.

The biodiversity of domesticated crop and livestock species, and the complex of wild species that directly support agriculture (such as wild pollinators), is also critically important to future prosperity and is also suffering from numerous threats. This book will address how increased agricultural diversity can enhance habitat for wild species, and how strategies to enhance wild biodiversity can build on the beneficial effects of many wild species for agricultural production and sustainability. However, it will not address the topic of genetic diversity of domesticated agricultural species, which has recently begun to receive wide attention from ministries of agriculture and the many agencies that support them (Gemmill, 2002).

As the distinguished British ecologist Norman Myers pointed out, 'It is in the common interest of both agriculture and the natural world that a mutually supportive relationship be developed between them. Production of food need not destroy the wild ecosystems of the world and their wealth of biological diversity. And preservation of wild ecosystems does not pose a threat to humanity feeding itself. In fact, just the opposite is true. Sensible use of nature, which includes substantially increased nature conservation efforts, is essential to feed the planet… Nature equals food. Without wild places, we cannot hope to have food on our tables' (Myers, 1987). And without healthy agriculture, we cannot expect nature to prosper.

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10

Resource-conserving Agriculture Increases Yields in Developing Countries

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Introduction

What is the best way to increase agricultural productivity in developing countries that still, despite efforts over several decades, have some 800 million people short of food? The question is controversial, with widely varying positions about the types of inputs and technologies likely to be effective (McNeely and Scherr, 2003; Smil, 2000; Tilman et al, 2002; Trewevas, 2002). Great technological progress in the past half century has not been reflected in major reductions in hunger and poverty in developing countries.

However, many novel initiatives have emerged that are demonstrating that agriculture in poor countries can be greatly improved. Here we evaluate how farmers in 286 projects in 57 countries have improved food crop productivity since the early- to mid-1990s, and at the same time increased both water use efficiency and carbon sequestration and reduced pesticide use. These initiatives also offer the prospects of resource conserving agriculture both reducing adverse effects on the environment and contributing to climate change mitigation.

In the past 40 years, per capita world food production has grown by 17 per cent, with average per capita food consumption in 2003 of 2780kcal day^{-1} (FAO, 2005), where a majority of the chronically hungry are small farmers who produce much of what they eat. Yet consumption in 33 poor countries is still less than 2200kcal day^{-1}. Food demand will both grow and shift in the coming decades, as: (i) population growth increases absolute demand for food; (ii) economic growth increases people's purchasing power; (iii) growing urbanization encourages people to adopt new diets; and (iv) climate change threatens both land and water resources.

Increased food supply is a necessary though not sufficient condition for eliminating hunger and poverty. What is important is who produces the food, has access

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to the technology and knowledge to produce it, and has the purchasing power to acquire it. The great success of industrialized agriculture in recent decades has masked significant negative externalities, with environmental and health problems increasingly well documented and costed, including in Ecuador, China, Germany, the Philippines, the UK and the US (Crissman et al, 1998; Norse et al, 2001; Pingali and Roger, 1995; Pretty et al, 2000; Tegtmeier and Duffy, 2004; Waibel et al, 1999). There are also growing concerns that such systems may not reduce food poverty. Poor farmers need low-cost and readily available technologies and practices to increase local food production and to raise their income. At the same time, land and water degradation is increasingly posing a threat to food security and the livelihoods of rural people who often live on degradation-prone lands (Uphoff, 2002).

The idea of agricultural sustainability centres on food production that makes the best use of nature's goods and services whilst not damaging these assets. Many different terms have come to be used to imply greater sustainability in some agricultural systems over prevailing ones (both pre-industrial and industrialized) (National Research Council, 2000). Agricultural sustainability in all cases, however, emphasizes the potential benefits that arise from making the best use of both good genotypes of crops and animals and their ecological management. Agricultural sustainability does not, therefore, mean ruling out any technologies or practices on ideological grounds (e.g. genetically modified crops, organic practice) – provided they improve productivity for farmers and do not harm the environment (Conway, 1997; National Research Council, 2000; Nuffield Council on Bioethics, 2004; Pretty, 2002; Uphoff, 2002).

In this research, we concentrate on projects that have made use of a variety of packages of resource-conserving technologies and practices. These include:

1 *Integrated Pest Management*, which uses ecosystem resilience and diversity for pest, disease and weed control and seeks only to use pesticides when other options are ineffective.
2 *Integrated nutrient management*, which seeks both to balance the need to fix nitrogen within farm systems with the need to import inorganic and organic sources of nutrients and to reduce nutrient losses through erosion control.
3 *Conservation tillage*, which reduces the amount of tillage, sometime to zero, so that soil can be conserved and available moisture used more efficiently.
4 *Agroforestry,* which incorporates multifunctional trees into agricultural systems and collective management of nearby forest resources.
5 *Aquaculture*, which incorporates fish, shrimps and other aquatic resources into farm systems, such as into irrigated rice fields and fish ponds, and so leads to increases in protein production.
6 *Water harvesting* in dryland areas, which can mean formerly abandoned and degraded lands can be cultivated and additional crops grown on small patches of irrigated land owing to better rain water retention.
7 *Livestock integration* into farming systems, such as dairy cattle and poultry, including using zero-grazing.

Here we show the extent to which recent successful interventions focusing on agricultural sustainability (sometimes called bright spots, see Scherr and Yadav, 1996) have increased total food crop productivity in developing regions. Our questions are:

1 To what extent can farmers increase per hectare and per farm food production by using low-cost and locally-available technologies and inputs?
2 What impacts do such methods have on environmental goods and services (in particular using the water use efficiency, carbon sequestration and pesticide use as proxies to indicate changes in adverse effects on the environment)?

Methodology

We used both questionnaires and published reports of projects to assess adoption of sustainable agriculture and changes over time. As in earlier research (Pretty et al, 2003), data were triangulated from several sources and cross-checked by external reviewers and regional experts. This study involves analysis of projects sampled once in time (n = 218) and those sampled twice over a four-year period to assess temporal changes (n = 68). Not all proposed cases were accepted for the data set, and rejections were based on a strict set of criteria (Pretty et al, 2003). As this was a purposive sample of 'best practice' initiatives, the findings are not representative of all developing country farms.

We used a novel typology of farming systems developed by FAO for the World Bank to classify these projects (Dixon and Gulliver, 2001) into eight broad categories based on the following social, economic and biophysical criteria:

1 the available natural resource base, including water, land, grazing areas and forest; climate and altitude; landscape, including slope; farm size, tenure and organizations; and access to services including markets;
2 the dominant patterns of farm activities and household livelihoods, including field crops, livestock, trees, aquaculture, hunting and gathering, processing and off-farm activities; and the main technologies used, which determine the intensity of production and integration of crops, livestock and other activities.

Table 10.1 contains a summary of the global land area and population located in these eight major farm system categories. On average, these sustain 2.28 people per cultivated hectare of land (range 0.5–5.5). A total of 72 farming subsystems have been identified across the developing regions, some of which comprised similar systems occurring on different continents (e.g. wetland rice systems in East Asia/Pacific and in South Asia). In our study, system categories 2–5 are well-represented,

Table 10.1 *Summary of FAO–World Bank farming system categories in developing regions and number of project entries for this study*

FAO farm system category	*Number of sub-systems*	*Land area (M ha)*	*Cultivated area (M ha)*	*Agricultural population (M)*	*Agricultural population per cultivated hectare*	*No. project entries for each category*
1. Smallholder irrigated	1	219	15	30	2.0	16
2. Wetland rice	3	330	155	860	5.5	55
3. Smallholder rainfed humid	11	2013	160	400	2.5	95
4. Smallholder rainfed highland	10	842	150	520	3.5	40
5. Smallholder rainfed dry/cold	19	3478	231	490	2.1	43
6. Dualistic mixed	16	3116	414	190	0.5	20
7. Coastal artisanal	4	70	11	60	5.5	2
8. Urban-based and kitchen garden	6	na	na	40	na	15
Total	72	10068	1136	2590	2.28	286

Source: from Dixon and Gilliver, 2001; na = not available

with 40–95 projects in each. System categories 1, 6 and 8 have 15–20 projects and category 7 has only two.

Extent of agricultural sustainability and impacts on yields

Table 10.2 contains a summary of the location and extent of the 286 agricultural sustainability projects across the eight categories of farming systems in 57 countries. In all, some 12.6 million (M) farmers on 37 M hectares were engaged in transitions towards agricultural sustainability in these 286 projects. This is just over 3 per cent of the total cultivated area shown in Table 10.1. The largest number of farmers was in wetland rice-based systems, mainly in Asia (category 2), and the largest area was in dualistic mixed systems, mainly in southern Latin America (category 6).

We were able to show that agricultural sustainability is spreading to more farmers and hectares. In the 68 randomly re-sampled projects from the original study, there was a 53.6 per cent increase over the four years in the number of farmers and 44.6 per cent in the number of hectares. These resurveyed projects comprised 60 per cent of the farmers and 43.7 per cent of the hectares in the original sample of 208 projects (Pretty et al, 2003). In the earlier study, we reported that 89 projects

Table 10.2 *Summary of adoption and impact of agricultural sustainability technologies and practices on 286 projects in 57 countries*

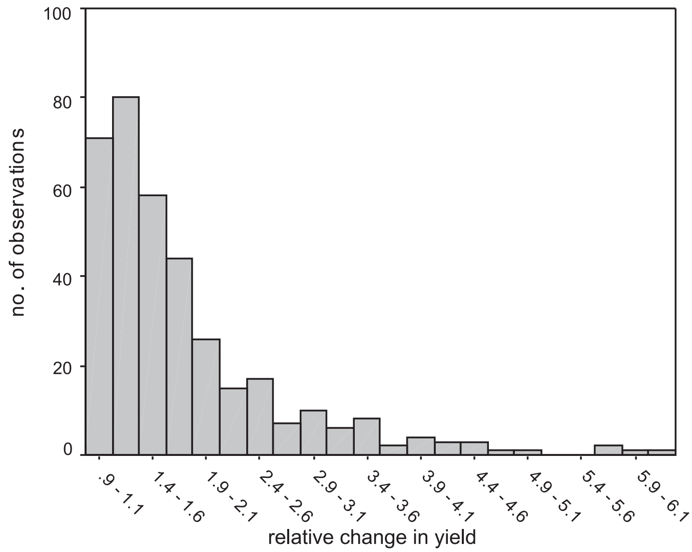
FAO farm system category	*Number of farmers adopting*	*Number of hectares under sustainable agriculture*	*Average % increase in crop yields*
1. Smallholder irrigated	177,287	357,940	129.8 (±21.5)
2. Wetland rice	8,711,236	7,007,564	22.3 (±2.8)
3. Smallholder rainfed humid	1,704,958	1,081,071	102.2 (±9.0)
4. Smallholder rainfed highland	401,699	725,535	107.3 (±14.7)
5. Smallholder rainfed dry/cold	604,804	737,896	99.2 (±12.5)
6. Dualistic mixed	537,311	26,846,750	76.5 (±12.6)
7. Coastal artisanal	220,000	160,000	62.0 (±20.0)
8. Urban-based and kitchen garden	207,479	36,147	146.0 (±32.9)
All projects	12,564,774	36,952,903	79.2 (±4.5)

Notes: Yield data from 360 crop project combinations; reported as % increase (thus a 100% increase is a doubling of yields). Standard errors in brackets.

for which there was reliable yield data showed increases in per hectare food production.

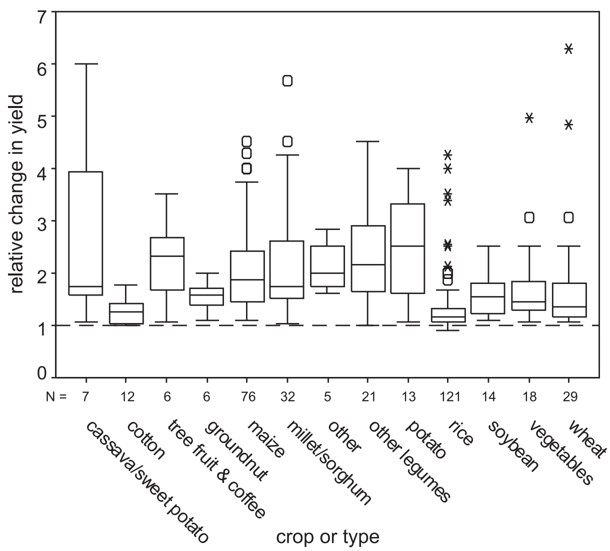
For the 360 reliable yield comparisons from 198 projects that we now have, the mean relative increase was 79 per cent across the very wide variety of systems and crop types. However, there was a wide spread in results (Figure 10.1). While 25 per cent of projects reported relative yields > 2.0 (i.e. 100 per cent increase), half of all the projects had yield increases of between 18 per cent and 100 per cent. The geometric mean is a better indicator of the average for such data with a positive skew, but this still shows a 64 per cent increase in yield. However, the average hides large and statistically significant differences between the main crops (Figures 10.2 and 10.3). In nearly all cases there was an increase in yield with the project. Only in rice were there three reports where yields decreased and the increase in rice was the lowest (mean = 1.35), although it constituted a third of all the crop data. Cotton showed a similarly small mean yield increase.

The mean (2.84) and spread was largest in cassava and sweet potato crops, although the sample is small. Soybean and groundnut showed mean increases of about 50 per cent. Maize, millet and sorghum, potatoes and the other legumes group (beans, pigeon peas, cowpea, chickpea) all showed mean yield increases of > 100 per cent, significantly higher than for cotton, rice and groundnut ($p < 0.05$). For most of the main field crops that are well represented in the survey, those with



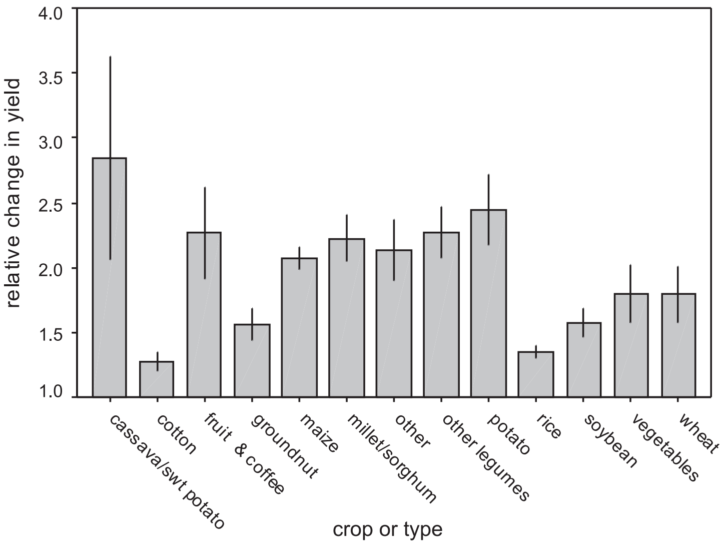
Notes: $n = 360$, mean = 1.79, s.d. 0.91, median = 1.50, geometric mean = 1.64.

Figure 10.1 *Histogram of change in crop yield after or with project, compared to before or without project*



Notes: Bold lines within boxes indicate median value, box limits indicate interquartile range (i.e. 50% of values lie within the box), whiskers indicate highest and lowest, excluding outliers (O, 1.5 to 3 × box length distance away from edge of box) or extremes (*, > 3 × box length). 'Other' group consists of sugar cane ($n = 2$), quinoa (1), oats (2).

Figure 10.2 *'Box and whisker plot' of change in crop yield after or with project, compared to before or without project*



Notes: Vertical lines indicate ± s.e.m. 'Other' group consists of sugar cane ($n = 2$), quinoa (1), oats (2).

Figure 10.3 *Mean changes in crop yield after or with project, compared with before or without project*

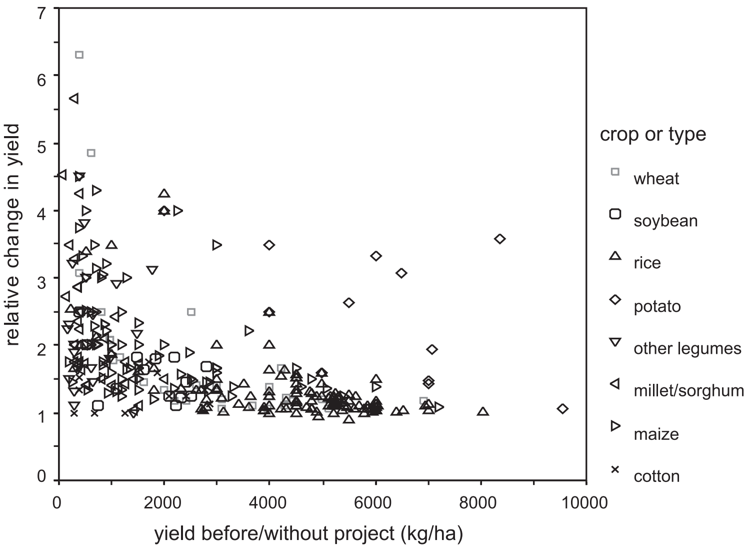
low yields before intervention often showed larger relative improvements, either because of growth limiting environments, or perhaps reduced investment in developing these crops, although potato showed large increases across the range (Figure 10.4).

Though many technologies and practices were used in these projects, three types of technical improvement are likely to have played substantial roles in food production increases:

1 more efficient water use in both dryland and irrigated farming;
2 improvements in organic matter accumulation in soils and carbon sequestration;
3 pest, weed and disease control emphasizing in-field biodiversity and reduced pesticide (insecticide, herbicide and fungicide) use.

Impacts on farm water use efficiency

Widespread appreciation of the 'global water crisis' recognizes that scarcity of clean water is affecting food production and conservation of ecosystems. By 2025 it is predicted that most developing countries will face either physical or economic water scarcity (International Water Management Institute, 2000). Water diverted from rivers increased six-fold between 1900 and 1995 (Shiklomanov, 1999), far



Note: Only field crops with n > 9 shown.

Figure 10.4 *Relationship between relative changes in crop yield after (or with project) to yield before or (without project)*

outpacing population growth. Increasing demand for fresh water now threatens the integrity of many aquatic ecosystems and their associated environmental services (Costanza et al, 1997). As agriculture accounts for 70 per cent of current water withdrawals from rivers, so improving the productivity of water use in agriculture is a growing challenge.

The potential for increasing food production while maintaining water-related ecosystem services rests on the capacity to increase water productivity (WP), i.e. by realizing more kg of food per unit of water. Sustainable agricultural practices may do this by: (i) removing limitations on productivity by enhancing soil fertility; (ii) reducing soil evaporation through conservation tillage; (iii) using more water efficient varieties; (iv) reducing water losses to unrecoverable sinks; (v) boosting productivity by supplemental irrigation in rainfed systems; and (vi) inducing microclimatic changes to reduce crop water requirements (Kijne et al, 2003). We calculated changes in WP for field crops in 144 projects from the data set (Table 10.3) based on reported crop yields and average potential evapotranspiration (ETp), for each project location during the relevant growing season. Actual evapotranspiration (ETa) was assumed to equal 80 per cent of ETp, and ETa to remain a constant at different levels of productivity.

WP gains were high in rainfed systems and moderate in irrigated systems, and were in agreement with other studies reporting ranges of WP (Kijne et al, 2003). The very large increase for the vegetables and fruits is probably an overestimate as

Table 10.3 *Summary of changes in water productivity by major crop type arising from adoption of sustainable agricultural technologies and practices in 144 projects*

Crops	*Water productivity before intervention (kg food m^{-3} water ETa)*	*Water productivity after intervention (kg food m^{-3} water ETa)*	*Water productivity gain (kg food m^{-3} water ETa)*	*% Increase in WP*
Irrigated				
Rice (*n* = 18)	1.03 (±0.22)	1.19 (±0.12)	0.16 (±0.04)	15.5%
Cotton (*n* = 8)	0.17 (±0.04)	0.22 (±0.05)	0.05 (±0.02)	29.4%
Rainfed				
Cereals (*n* = 80)	0.47 (±0.06)	0.80 (±0.09)	0.33 (±0.05)	70.2%
Legumes (*n* = 19)	0.43 (±0.07)	0.87 (±0.16)	0.44 (±0.11)	102.3%
Roots and tubers (*n* = 14)	2.79 (±0.73)	5.79 (±1.08)	3.00 (±0.65)	107.5%
Urban and kitchen gardens				
Vegetables and fruits (*n* = 5)	0.83 (±0.29)	2.96 (±0.97)	2.13 (±0.71)	256.6%

Note: Standard errors in brackets.

we did not adjust ETp for new crops or lengthened cropping periods. Variability was high due to the wide variety of practices represented in the data set, but do indicate that gains in WP are possible through the adoption of sustainable farming technologies in a variety of crops and farm systems. Our results, and others (Agarwal and Narain, 1997; Rockström and Falkenmark, 2000), demonstrate that the greatest opportunity for improvement in water productivity is in rainfed agriculture. Better farm management, including supplemental irrigation and fertility management, can significantly reduce uncertainty and thus avoid chronic low productivity and crop failure that are characteristic of many rainfed systems.

Impacts on carbon sequestration

The 1997 Kyoto Protocol to the UN Framework Convention on Climate Change established an international policy context for the reduction of carbon emissions and increases in carbon sinks in order to address the global challenge of anthropogenic interference with the climate system. It is clear that both emission reductions and sink growth will be necessary for the mitigation of current climate change trends (IPCC, 2001; Lal et al, 2004; Swingland, 2003). Carbon sequestration is defined as the capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere (Watson et al, 2000).

One of the actions farmers can take is to increase carbon sinks in soil organic matter and above-ground biomass. We calculated the potential annual contributions

Table 10.4 *Summary of potential carbon sequestered in soils and above-ground biomass in the 286 projects*

FAO farm system category	*Carbon sequestered per hectare ($t\ C\ ha^{-1}\ y^{-1}$)*	*Total carbon sequestered ($Mt\ C\ y^{-1}$)*	*Carbon sequestered per household ($t\ C\ y^{-1}$)*
1. Smallholder irrigated	0.15 (±0.012)	0.011	0.06
2. Wetland rice	0.34 (±0.035)	2.530	0.29
3. Smallholder rainfed humid	0.46 (±0.034)	0.340	0.20
4. Smallholder rainfed highland	0.36 (±0.022)	0.230	0.56
5. Smallholder rainfed dry/cold	0.26 (±0.035)	0.200	0.32
6. Dualistic mixed	0.32 (±0.023)	8.030	14.95
7. Coastal artisanal	0.20 (±0.001)	0.032	0.15
8. Urban-based and kitchen garden	0.24 (±0.061)	0.015	0.07
Total	0.35 (±0.016)	11.380	0.91

Note: Standard errors in brackets.

being made in these 286 projects to carbon sink increases in soils and trees, using established carbon audit methods (Pretty et al, 2002) (Table 10.4). As the focus is on what sustainable methods can do to increase quantities of soil and above-ground carbon, we did not take account existing stocks of carbon. Soil carbon sequestration is corrected for climate, as rates are higher in humid compared with dry zones, and generally higher in temperate rather than tropical areas (Lal et al, 2004; Watson et al, 2000).

These projects were potentially sequestering 11.4 Mt C y^{-1} on 37 M ha. If scaled up, assuming that 25 per cent of the areas under the different farming system categories globally (Table 10.1) adopted these same sustainability initiatives, this would result in sequestration of 100 (±4) Mt C y^{-1}. The average gain was 0.35 (±0.016) t C ha^{-1} y^{-1}, and an average gain per household of 0.91 t C y^{-1}. The per hectare gains vary from 0.15 (±0.012) t C ha^{-1} y^{-1} for smallholder irrigated systems (category 1) to 0.46 (±0.034) t C ha^{-1} y^{-1} for category 3 systems. For most systems, per households gains were in the range 0.05–0.5 t C y^{-1}, with the much larger farms of southern Latin America using zero-tillage achieving the most at 14.9 t C y^{-1}. Such gains in carbon may offer new opportunities for income generation under carbon trading schemes.

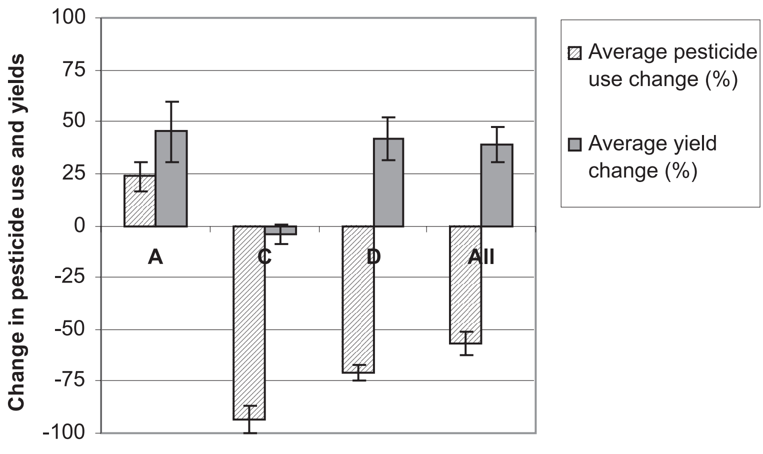
Impacts on pesticide use

Integrated Pest Management (IPM) programmes are beginning to show how pesticide use can be reduced and modified without yield penalties in a variety of farm systems, such as in irrigated rice in Asia (Eveleens, 2004) and rainfed maize in Africa (Khan et al, 1997). In principle, there are four possible trajectories an agricultural system can take if IPM is being introduced:

1 both pesticide use and yields increase (A);
2 pesticide use increases but yields decline (B);
3 both pesticide use and yields fall (C);
4 pesticide use declines, but yields increase (D).

The conventional wisdom is that pesticide use and yields are positively correlated, and so only trajectories moving into A and C are likely (Knutson et al, 1990; Schmitz, 2001). A change into sector B would be against economic rationale, as farmers' profits would invariably fall and behaviour change. A shift into sector D would indicate that current pesticide use has negative yield effects. This could be possible with an excessive use of herbicides or when pesticides cause outbreaks of secondary pests (Kenmore et al, 1984). We analysed the 62 IPM initiatives in 21 developing countries in the data set (Figure 10.5). The evidence on pesticide use is derived from data on both the number of sprays per hectare and the amount of active ingredient per hectare. There is only one case in sector B reported in recent literature (Feder et al, 2004), and so this was not included.

Sector A contains ten projects where pesticide use increased. These are mainly in zero-tillage and conservation agriculture systems, where reduced tillage creates benefits for soil health and reduces off-site pollution and flooding costs. These



Notes: A: $n = 10$; C: $n = 5$; D: $n = 47$.

Figure 10.5 *Changes in pesticide use and yields in 62 projects* systems usually require increased use of herbicides for weed control (de Freitas, 1999), though there are examples of organic zero-tillage systems (Petersen et al, 2000). The five cases in sector C show a 4.2 per cent (±5.0) decline in yields with a 93.3 per cent (±6.7) fall in pesticide use. Most cases, however, are in category D where pesticide use declined by 70.8 per cent (±3.9) and yields increased by 41.6 per cent (±10.5). While pesticide reduction is to be expected, as farmers substitute pesticides with information, the cause of yield increases induced by IPM are complex. It is likely that farmers who receive good quality field training will not only improve their pest management skills but also become more efficient in other agronomic and ecological management practices. They are also likely to invest cash saved from pesticides in other inputs such as higher quality seeds and fertilizers. This analysis indicates a considerable potential for avoiding environmental costs.

Discussion

It is uncertain whether progress towards agricultural sustainability, delivering benefits at the scale occurring in these projects, will result in enough food to meet the future food needs in developing countries after continued population growth, urbanization and the dietary transition to meat-rich diets (Delgado et al, 1999). Even the substantial increases reported here may not be enough. However, more widespread adoption of these resource conserving technologies, combined with other innovations in crop and livestock genotypes, would contribute to increased agricultural productivity (Nuffield Council on Bioethics, 2004; Trewevas, 2002), particularly as evidence indicates that productivity can grow in many farming systems as social and human capital assets also grow (Pretty, 2003). Our findings also show that poor households benefit substantially.

But improving agricultural sustainability will not alone solve all food poverty problems. The challenge is to find ways to improve all farmers' access to productive technologies and practices that are also resource conserving. The critical priority is now international, national and local policy and institutional reforms (Dasgupta, 1998) designed to benefit both food security and income growth at national and household levels, whilst improving the supply of critical technologies that improve the supply of environmental goods and services.

Acknowledgements

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Supporting information

See Dixon and Gulliver (2001) for full details of the classification system developed by FAO. This separates farming systems into eight types (irrigated; wetland rice based; smallholder rainfed humid; smallholder rainfed highland; smallholder rainfed dry/cold; dualistic; coastal artisanal fishing; urban-based) for six regions of the world (sub-Saharan Africa; Middle East and North Africa; Europe and Central Asia; South Asia; East Asia and Pacific; Latin America and Caribbean).

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Part III

Diet and Health

11

Whole Diets

E. Balfour

In the Introduction to his book, *The Wheel of Health*,[1] Dr Wrench makes this thought-provoking statement: 'After debating the question – Why disease? Why not health? – again and again with my fellow students, I slowly, before I qualified, came to a further question – Why was it that as students we were always presented with sick or convalescent people for our teaching and never with the ultra healthy? Why were we only taught disease: why was it presumed that we knew all about health in its fullness? The teaching was wholly one-sided. Moreover, the basis of our teaching upon disease was pathology, namely, the appearance of that which is dead from disease.'

This view, that the professional attitude to sickness is one-sided is shared by the compilers of the PEP Report (1936) on the British Health Services. The authors express it as follows:

> Health means more than not being ill. A new attitude is needed, involving not so much a departure from the old as a more thorough grasp of the different elements in health policy. Many people are at any given moment suffering from defects, injuries or sickness so pronounced as to make them unable to carry on ordinary occupations and leisure activities. These are the 'cases' with which a large part of the organized health services mainly deal. But in addition there are far larger numbers of people suffering temporarily or permanently from less acute defects, injuries, or inadequacies, which are not sufficient to unfit them for work or play, and may not even be noticed at all, but nevertheless suffice to place them in an unnecessarily weak position for creating and maintaining good physique, energy, happiness, or resistance to disease... No contemporary health policy can be considered adequate which does not deal with the second group as well as the first...
>
> While efforts at effecting the cure of diseases cannot be relaxed, efforts at prevention of ill health can and must be increased. The aspect of raising standards of nutrition and of fitness should be given much prominence. Health must come first: the mere state of not being ill must be recognized as an unacceptable substitute, too often tolerated or even regarded as normal. We must, moreover, face the fact that while immense study has been lavished on disease no one has intensively studied and analysed health,[2] and our

Reprinted from Balfour E. 1943. Whole diets, in Balfour E. *The Living Soil*, Faber and Faber, London. Chapter 7, pp161–179.

> ignorance of the subject is still so deep that we can hardly claim scientifically to know what health is.

The theory which I have endeavoured to expound in this book [*The Living Soil*] is that the only true conception of health is one of wholeness, dependent upon both the continuity and the completeness of the cycle of life. I shall make no attempt to discuss the philosophical aspect of this conception, I am concerned only with presenting certain evidence suggesting that it is biologically sound. For the sake of clarity in this presentation, the argument has been divided into two parts. The first states that the determining factor in health is food, and the second suggests that the health-giving property of food is dependent on the way it is grown, prepared and consumed.

There is always an inherent danger in making arbitrary divisions where no true division exists, but in the present case this could hardly be avoided. The risk of failing to see the wood for the trees must sometimes be taken in order to discover how large a number of trees go to make a wood. In the previous chapters [of *The Living Soil*] – to pursue the same analogy – I have invited you to examine some of the trees. In this chapter I want you to take a look at the wood as a whole. This, research has, so far, largely failed to do. Research workers in chemistry, biology, mycology, botany, veterinary science and medicine, have for too long been working in watertight compartments, each busily dissecting his own tree, until in the process the wood has become so sadly dismembered it is small wonder that we sometimes cease to be aware of its existence.

It may be objected that I have followed their example of fragmentation in laying so much stress on the role of the fungus in nutrition. In so far as this accusation is well founded, my defence is that this is the link in the life cycle which is most frequently omitted, but which is at the same time the easiest to restore. In emphasizing its importance, however, I have never intended to suggest that it forms other than a part, however important in itself, of the complete cycle of nutrition and health which is wholeness.

McCarrison in the Cantor Lectures states: 'The diet of the Sikhs is only health-promoting so long as it is consumed in its entirety', and as Dr Wrench points out, with their whole diet these people 'have preserved the wholeness of their health, a thing which we have failed to do'.

> In the writings of the scientific experts on nutrition, there are very numerous part-diet experiments based on synthetic or specially made-up diets, omitting or cutting down the quantity of one or more of the factors which compose a diet. One scientist will cut down the quantity of protein given and watch the effect of this upon animals; another will cut down the fats and note the resulting sicknesses; another will give vegetable or irradiated vegetable fats in places of customary animal fats; another will give a diet in which vitamin A is defective, B is defective, C is defective, and so on.
>
> The experiments are skilfully devised and carried out with consumate technique. They lead to a mass of knowledge about proteins as things in themselves; fats as things

> in themselves; vitamins as things in themselves; but whether these can be things in themselves and are not really relative to a host of other conditions in nutrition is as yet scarcely considered...
>
> Our health or wholeness has fragmented no less than our diet. A swarm of specialists have with the invention of science settled on the fragments to study them. A great deal is found out about each several disease; there is a huge, unmanageable accumulation of knowledge, and this and that disease is checked or overcome. But our wholeness has not been restored to us. On the contrary, it is fragmented into a great number of diseases and still more ailments. We have lost wholeness, and we have got in its place its fragmentation with a multiplexity of methods, officially blessed and otherwise, dealing with the fragments in their severally.

This fragmentation has resulted, among other things, in a host of contradictory views among dietitians, each one of the different diets advocated possessing a company of followers ready to argue its exclusive merits with almost religious fervour. Thus you have the vegetarian; the fruitarian; those who never eat proteins and starch at the same meal; and those who stew all their foods together in the same pot; those that say you must drink before meals; others that believe in drinking after meals; those that drink between meals, and besides all these, and many more, there is the vast majority that eat what they want when they want it (or can get it) and drink when they are thirsty. This majority is given to labelling all the others as faddists, and indeed there does not seem to be a very noticeable difference in health between any of these groups. No wonder then, that the average person is apt to be a little sceptical when he is told that health depends on diet.

What then should be the reply to the would-be seeker after health who asks: 'What shall I eat that I may be whole?'

For an answer let us go to those people from whom Dr Wrench, in his student days, felt instinctively that such knowledge should be sought, namely the ultra-healthy. Not the occasional individual of whom one says that he is 'abnormally healthy' (a revealing adverb) but to whole groups of people to whom a state of full health is normal.

Five such groups exist, or have existed, about which a good deal of statistical data is available. We will examine these in turn, noting how they live and what they eat, and see if we can discover among them a common factor of which it permissible to say – here lies the secret of health.

We will take first the people of Hunza, a small native state in the extreme northernmost part of India attached to the Gilgit Agency. The origin of these people is somewhat of a mystery. Both in physical characteristics and language they differ from their neighbours, and indeed from all the other peoples of the Indian subcontinent. Only one thing seems certain, that they have inhabited their valley since the extremely distant past. The massive stone walls, the building of which must have preceded their admirable terraced agriculture, have a parallel only in the masonry left by the Peruvian civilization which preceded the Inca conquest.

The Hunza valley is a gorge running east and west cleft in a towering mountain range. It is arid in summer and bitterly cold in winter, but owing to the system of irrigation, it is extremely fertile and an immense variety of fruits and vegetables are cultivated by these industrious people.

Something of their superb health and stamina has already been indicated in Chapter 2 [of *The Living Soil*]. All travellers passing through their valley speak of their outstanding physique, courage and good humour. McCarrison, who for some time was Medical Officer to the Gilgit Agency, has said of them:

> These people are unsurpassed by any Indian race in perfection of physique. They are long lived, vigorous in youth and age, capable of great endurance and enjoy a remarkable freedom from disease in general.
>
> During the period of my association with these people I never saw a case of asthenic dyspepsia, of gastric or duodenal ulcer, of appendicitis, of mucous colitis, of cancer...
>
> Among these people the 'abdomen over-sensitive' to nerve impressions, to fatigue, anxiety, or cold was unknown. The consciousness of the existence of this part of their anatomy was, as a rule, related solely to the feeling of hunger. Indeed, their buoyant abdominal health has, since my return to the West, provided a remarkable contrast with the dyspeptic and colonic lamentations of our highly civilized communities.

They are admirable cultivators:

> far famed as such and 'conspicuously ahead of all their neighbours in brain and sinew' stated Shomberg. Their big irrigation conduit, the Berber, is 'famous everywhere in Central Asia...'
>
> Amongst the peoples of the Agency not only are they 'as tillers of the soil quite in a class apart, they alone – and this always strikes me as truly remarkable – are good craftsmen.' As carpenters and masons, as gunsmiths, ironworkers, or even as goldsmiths; as engineers for roads, bridges or canals, the Hunza men are outstanding.

The Hunza are favoured in their fertile valley, but their perfect health cannot be put down to the locality in which they live, for next door to them is another, and equally fertile, valley, also running east and west and separated from Hunza only by a 20,000-foot mountain wall. In this valley live the Ishkomanis. These people, 'though living under apparently like conditions to their neighbours, were poor, undersized, undernourished creatures. There was plenty of land and water, but the Ishkomanis were too indolent to cultivate it with thoroughness; and the possibility of bad harvests was not enough to overcome their sloth… "They had no masons or carpenters or craftsmen in their country. Many of them showed signs of disease."'

We can thus rule out climate as the secret of the Hunza health. Now, let us look at their mode of life and their diet. For ten months of the year they can be said to live in the open air, for men, women and children work in the fields. They remain mainly indoors during the period of severe winter storms, but their houses are better, and better ventilated than those of their neighbours, their sanitation is also better and follows the 'immemorial custom of the Far East'. Unusual care is also taken to protect their drinking water by storing it in separate covered cisterns.

Their diet is a very varied one. It consists of

> wheat, barley, buckwheat, and small grains; leafy green vegetables; potatoes (introduced half a century ago), other root vegetables; peas and beans, gram or chick pea, and other pulses; fresh milk and buttermilk or lassi; clarified butter and cheese; fruit, chiefly apricots and mulberries, fresh and sun-dried; meat on rare occasions; and sometimes wine made from grapes. Their children are breast fed up to three years, it being considered unjust to the living child for its lactation to be interrupted by a maternal pregnancy.
>
> The Hunza do not take tea, rice, sugar or eggs. Chickens in a confined area destroy crops and are not kept.

Except for the wider range of small grains and the very occasional meat, this closely resembles any European lacto-vegetarian diet, and, at first sight, seems to support the view so widely held by nutrition experts, McCarrison among them, that of all diets the lacto-vegetarian is the healthiest. That it is a good diet is incontestable; it will, however, presently be shown that there are other peoples whose health and stamina is equal to that of the Hunza whose diet is the very opposite of theirs.

The Hunza foods then are not unlike our own, but there are important differences in the normal methods of preparation and cooking. Both we and the Hunza are great bread-eaters, and both prefer wheat bread, but the Hunza wheat is eaten freshly ground, and the unleavened bread made with it invariably contains the whole of the grain, with its vital germ and its protective skin, both of which are removed in the process of milling white flour.

Dr Wrench, writing on the properties of skin in general, points out that skin does not protect only in a mechanical way as a mere covering, but in a living way. All skins 'can regrow themselves if injured, and beneath and within them they store substances upon which they can call to strengthen their efforts'. The value of bran, the skin of wheat, is well known to all stock feeders. All carnivorous animals relish the skins of their prey. The Greenlanders, Wrench points out, eat the skin of the narwhal: 'The Chinese and other peoples also eat the skins of animals and birds. Everything living has a skin of some sort to protect it. It protects it by its extra toughness, but also if microbes and other minute enemies do attack, it is there on the frontier that the battle is waged. In and near the skin are marshalled the protective forces. Any creature that eats the skin of vegetable, fruit, or animal, also eats these protective materials marshalled on the frontier, and may benefit in its own protection thereby. Whether such a pretty hypothesis is true or not, there are suggestions that skins possess a peculiar value… The skin and adjacent part of the potato is the best part, as the Irish know. So also is it the case with the carrot, and, it is said, with young marrows, cucumbers, gherkins, artichokes, radishes, and celery. There is, therefore, a little evidence for the hypothesis.'

A fondness for skin is an outstanding feature of the Hunza, they do not peel their vegetables, or wash and soak them to the extent we do. Vegetables play a great part in their diet and are very commonly eaten raw. 'They are fond of raw green corn, young leaves, carrots, turnips, and, as it were to exaggerate their veneration for freshness, they sprout their pulses and eat them and their first green. This eating of sprouting pulse or gram is widespread in northern India, and undoubtedly within it there is a health which there is not in the pulse itself.'

Fuel in Hunza is scarce, and when they do cook their vegetables they are boiled in covered pots as is the usual habit in this country.

'But the process is more comparable to our way of steaming and cooking in their own juice. Very little water is added. When this has been used up more is added. The water in which the vegetables are cooked is drunk either with the vegetables or later. The point is that it is part of the food. It is not thrown away.'

This taking of vegetable water is obviously sensible, for many of the valuable mineral salts which vegetables contain pass into the water in which they are cooked, particularly if the vegetables are peeled before cooking. 'There is abundant evidence from the scientists of the loss that occurs through the throwing away of vegetable water of phosphorus, calcium, iron, iodine, sulphur, etc. Quite a considerable proportion of the pharmacopoeia seems to have arisen owing to this waste. Quite a considerable number of the doctors' prescriptions and patent medicines may be due to the need to replace the salts of the food in those who suffer from this loss. The similarity of the medicines and the lost salts is too close for one not to be profoundly suspicious that the methods of cooking cause or contribute to the subsequent need of the medicines.'

The Hunza drink milk in considerable quantity, they drink it whole and they boil the fat from it to form clarified butter or ghee, which they spread on their bread and also use for cooking. They drink the buttermilk which remains, and both this and their whole milk they preserve in hot weather by souring. Meat is a 'rare pleasure', most of their livestock being dairy animals. They rarely eat meat more than once in ten days, and often only about once a month. When they do, they eat all that is edible in the carcass and stew it together with their vegetables and pounded wheat. But ranking above all the foregoing in the Hunza diet is fruit. '"The Hunza are great fruit eaters, especially of apricots and mulberries. They use apricots and mulberries in both the fresh and dry state, drying sufficient of their rich harvest of them for use throughout the autumn and winter months." (McCarrison.) They eat the fruit fresh in season, cracking the stones and eating the kernels as well. Otherwise they take them, particularly sun-dried apricots, and eat them as they are, or rub them in water to form a thick liquid called *chamus*. Dried mulberries they put into cakes as we do sultanas. They do not cook their fruits. "Fruit is really the Hunza staple. It is eaten with bread, far more so than vegetables, as it is more abundant."' (Schomberg.) '"Even the animals," said Durand, "take the fruit diet, and you see donkeys, cows and goats eating the fallen mulberries. The very dogs feed on them, and our fox-terriers took to the fruit regimen most kindly and became quite connoisseurs."' They ferment some of their fruit juices and on festive occasions drink their own home-made wine.

So far the main differences between the Hunza diet and our own seems to be that the Hunza foods are all natural foods, they are eaten fresher than ours, and they are consumed whole, but there is one more difference, the most fundamental of all, and this lies in the way in which these foods are grown.

In their system of agriculture which has been continued 'century after century' the chief factors in their plant food have been two.

> Firstly, there is the continuous slight renewal of the soil by a sprinkling of the black glacier-ground sand, which is brought to the fields by the aqueducts.
>
> Secondly, there is the direct preparation by man of food for the plants, given in the form of manure.
>
> The Hunza, in their manuring, use everything that they can return to the soil. They carefully collect the cattle manure and store it in the byres. They collect all vegetable parts and pieces that will not serve as food to either man or beast, including such fallen leaves as the cattle will not eat, and mix them with the dung and urine in the byres. They use the human sewage after keeping it for six months. They take silt from special recesses built in their irrigating channels. They collect the ashes of their fires. All these they mix together and make into a compost. They also spread alkaline earth from the hills on their vegetable fields on days when the fields are watered.

O. F. Cook of the Bureau of Plant Industry of the US Department of Agriculture has written: 'Agriculture is not a lost art, but it must be reckoned as one of those which reached a remarkable development in the remote past and afterwards declined.' As an example he cites the system of the ancient Peruvians which enabled them to support large populations in places 'where modern farmers would be helpless'.[3]

Travellers who have visited both Peru and the North-West Indian Provinces have been struck by the resemblance between the stone aqueducts and mammoth walls that support the terraced fields of both areas. Describing those of Hunza the late Lord Conway wrote:

> The path that leads up to Baltit[4] is bordered on either side by a wall of dry cyclopean masonry the undressed component parts of which are very large and excellently fitted together … a monumental piece of simple engineering … the valley between the cliffs and the edge of the river's gorge is covered with terraced fields… The cultivated area of the oasis is some five square miles in extent. When it is remembered that the individual fields average as many as twenty to the acre, it will be seen what a stupendous mass of work was involved in the building of these walls and the collection of earth to fill them. The walls have every appearance of great antiquity, and alone suffice to prove the long existence in this remote valley of an organized and industrious community…
>
> To build these fields was the smaller part of the difficulties that husbandmen had to face in Hunza. The fields also had to be irrigated. For this purpose there was but one perennial supply of water – the torrent from the Ultar glacier. The spout of that glacier, as has been stated, lies deep in a rock-bound gorge, whose sides are for a space perpendicular cliffs. The torrent had to be tapped, and a canal of sufficient volume to irrigate

> so large an area had to be carried across the face of one of these precipices. The Alps contain no *Wasserleitung* which for volume and boldness of position can be compared to the Hunza canal. It is a wonderful work for such toolless people as the Hunzakats to have accomplished, and it must have been done many centuries ago and maintained ever since, for it is the life-blood of the valley.

Thus it can be seen that the Hunza appear to form a direct link between the present day and that 'remote past' in which agriculture reached such a 'remarkable development'. They are a people perhaps as ancient as the Incas, but who, unlike the Incas, have survived, and in their survival have preserved their ancient lore, and in the preservation of that lore have preserved the wholeness of their health and that of their crops and livestock, which Dr Wrench tells us is on a par with their own.

The blight which Western civilization usually casts on such people, has so far escaped them. Whether it will continue to do so is another matter. Since they have come under British suzerainty their population has increased from about six thousand to fourteen thousand, and this has resulted in a shortage of food in the preharvest period:

> Colonel D. L. Lorimer, who was Political Agent at Gilgit, 1920–4, and revisited the Hunza and lived amongst them at Alibad, 1933–4, four miles from the capital, Baltit, told me that not only did they seem smaller to him at his second visit, but that the children appeared under-nourished for the weeks preceding the first summer harvests half-way through June; and, moreover, that the children suffered at that time of the year from impetigo, or sores of the skin, all of which vanished when the more abundant food came.

A sign, incidentally, that it is not by virtue of their race, or habitat, or housing, that they are normally immune from bodily ailments.

We will now go from Latitude 37 to the northern and Arctic regions: from the lacto-vegetarian diet of the Hunza to the carcass diet of the islanders of Faroe, Iceland and Greenland. Early records of these peoples show them to have been every whit as healthy as the Hunza, yet these people are, or were, almost entirely carnivorous.

> These Danish possessions are three isolated lands from which no Western civilized person would expect to glean wisdom. But, as we have already seen in the case of food and health, isolation locks up the most valuable secrets. The peoples of these three lands, living either near or actually within the Arctic Circle, offer in three degrees, from Faroe to Greenland, an increasingly animal-fish-bird diet. It must not be called a meat diet; that is inaccurate as will be seen. It was largely a diet from the sea, and with the great health of the sea, a 'soil' outside the realms of terrestrial man.
>
> The diet of the Faroe Islanders, when they were more isolated than now, was given in a book published by the Edinburgh Cabinet Library in 1840. It was mainly a whole-carcass diet of animal, bird and fish. The islanders ate not merely meat, but everything

that could be eaten. There was no such thing as offal. They also made the carcasses gamey by hanging for weeks and even months. In addition to their whole-carcass food they had barley meal, unleavened barley bread, a few vegetables such as cabbages, parsnips and carrots.

They drank milk, beer, and, on festive occasions, brandy. But the main food was animal, bird and fish.

The islanders numbered a few thousands, were of the same origin as the Icelanders, and were, 'in general, remarkably intelligent. They are extremely healthy, and live to a great age, and an old man of ninety-three years lately rowed the governor's boat nearly ten miles.' One danger they incurred was an epidemic catarrhal fever, such as we call influenza, which 'prevails after the arrival of the ships from Denmark in the spring', after the winter's scarcity. It spreads rapidly and was sometimes fatal. Otherwise, 'but few diseases are prevalent amongst them'.

The inhabitants of Iceland offer a similar and even more interesting picture of carcass diet. McCollum and Simmonds, in *The Newer Knowledge of Nutrition* (1929) summarize the chief facts. 'This island was settled in the 9th century by colonists from Ireland and Scandinavia, who took with them cattle, sheep and horses. Their diet was practically carnivorous in nature for several hundred years. Martin Behaim (quoted by Burton), writing of Iceland about 1500, stated: "In Iceland are found men of eighty years who have never tasted bread. In this country no corn is grown, and in lieu, fish is eaten."'

Burton, quoting Pearse, states that rickets and caries of the teeth were almost unknown in Iceland in earlier times… The health conditions were good and dental caries was unknown until after 1850. Stefansson exhumed 96 skulls from a cemetery dating from the 9th to the 13th centuries and presented them to Harvard University. They have been described by Hooton (1918), who found no evidence of caries in any of them. There were but three to four defective teeth in the entire series, and these had suffered mechanical injury. During the last half century caries has steadily increased in Iceland.

Modern Iceland had not the isolation of the period which Burton described. There had been a great advance in civilization and population. Fifty per cent of the people now live in towns or trading stations. There are four agricultural schools. Potatoes, turnips, and rhubarb are cultivated. Iceland imports the trade foods, such as flour, sugar, preserved fruits and tinned foods. Caries has become common, as have many other ailments.

That this regrettable decline in health cannot be attributed to the change from country to town life, is proved by a remarkable experiment carried out in Denmark itself during World War I.

The blockade, following the entry of the USA into the war, put the Danes in a very serious position. Professor Mikkel Hindhede, Superintendent of the State Institute of Food Research, was made Food Adviser to the Danish Government to deal with it.

The problem that faced him was this; Denmark had a population of 3,500,000 human beings and 5,000,000 domestic animals. She was accustomed to import grains from the US for both. There was now a shortage of grain foods.

In this crisis Hindhede decided that a drastic reduction in the livestock must be made. So some four-fifths of the pigs were killed and about one-sixth of the cattle. Their grain food was given to the Danes, and it was given … as wholemeal bread with the extra coarse bran that is not put into ordinary wholemeal bread, incorporated.

In addition to this bread, or Kleiebrot, which was made official for the whole country, the Danes ate porridge, green vegetables, potatoes and other root vegetables, milk, butter, and fruit. No grain or potatoes were allowed for the distillation of spirits, so there were no spirits. Half the previous quantity of beer was permitted.

As some pigs were left, the people on the farms got meat; the people in the cities – 40 per cent of the population – got very little meat. Only the rich could afford beef.

The food regulations were begun in March 1917 and were made stringent from October 1917 to October 1918.

The result of this enforced national diet was a remarkable lowering of the deathrate. The deathrate, which had been 12.5 in 1914, now fell to 10.4 per thousand, 'which is the lowest mortality figure that has been registered in any European country at any time'. (Hindhede.)

Hindhede puts this impressive result in another way. Taking the average from 1900 to 1916 as 160, in the October to October year it was 66. Even in men over 65 the figure fell to 76.

Hindhede attributes this extraordinarily rapid and marked change to two things: (1) less meat, (2) less alcohol. He regards the bran as having largely filled the gap of the scanty or absent meat, bran having a good proportion of vegetable meat or protein. He regards the experiment as a triumph for his previous teaching. 'The reader knows,' he writes in the *Deutsche Medizinische Wochenschrift* of March 1920, 'how sharply I have emphasized the advantages of a lacto-vegetarian diet. I am not in principle a vegetarian, but I believe I have shown that a diet containing a large amount of meat and eggs is dangerous to health.'

And yet we have only to turn to another Danish possession (ironically enough) to find a refutation of this rather narrow view.

The north-west coast of Greenland, where the Polar Eskimos live, is within the Arctic Circle. It is the most isolated and the least affected by civilization of these three possessions of Denmark.

Some attempts at gardening have been introduced by the Danes, but previously the only vegetable food the Eskimos got was from the profuse but, in species, limited vegetation of the Arctic summer. Otherwise they lived mainly on sea animals and sea birds. There was no offal. They ate everything that could be eaten. When it was frozen they often ate it raw. The thick, heavy skin of the narwhal is particularly favoured. The millions of sea birds which visit their coast supply a winter store of meat and eggs.

The Eskimos are also exceptionally healthy. 'The fact that the Eskimos of this polar tribe have such excellent physique, hair, and teeth, and such superb health without any trace of scurvy, rickets, or other evidence of malnutrition,' write McCollum and Simmonds, 'is interesting in the light of their restricted and simple diet.'

> It is also interesting as a counterweight to Hindhede and other nutritionists who plump for the excellent lacto-vegetarian diet. There are other excellent diets, and the whole-carcass one of the Polar Eskimos is one of them.

From the far north our next jump is to the Island of Tristan da Cunha in the South Atlantic.

> The people of this island are people of our own race living on the products of sea and soil, most of them have perfect teeth which last them all their lives…
>
> Mr James R. A. Moore, LDS, RCS (Eng), visited the island in 1932 and again in 1937. In 1932 he examined 156 persons and 183 in 1937. Of the 3181 permanent teeth in the former year, there were 74 carious and of the 3906 in the latter year there were 179 carious.
>
> He speaks of the physique of the people as being good. They are well set up, clean and well nourished. The children are breast fed and are not weaned until at least one year old. Fish and potatoes are the staple diet, meat occasionally, milk and butter sufficient. Eggs form a big item of the island diet and are mainly Mollyhawk and penguin. Vegetables are not plentiful, but beetroot, lettuce, beans and onions are now being grown. Imported flour and sugar are regarded as luxuries, but they have been brought in to a greater extent latterly, which may account for the tendency of the teeth to deteriorate.
>
> The fat in adequate amount is provided by rendering down the carcasses of young Mollyhawks and petrels and is used extensively for frying. Sea water is evaporated to provide salt.[5]

It will be seen that the people of this island, also noted for their sound health,[6] have a more varied diet than that of the Eskimo, though like them much of it is derived from the sea. Eggs form a large part of their diet – one of the items condemned by Hindhede. It is worth noting that a marked difference exists between the methods of cooking adopted by the Tristan Islanders and the Hunza, for whereas the latter cook everything together in one pot, the people of Tristan never partake of more than one kind of food at the same time.

For our fourth example of a (once) superlatively healthy race, we must go to the North American Indian of the pioneer days. Observation of these people since they have been forced to live in reservations has been very carefully recorded.

> All who observed the Indians in their primitive state agree that most of them were exceptional specimens of physical development. With few exceptions, however, during two generations, they have deteriorated physically. The reason for this is apparently brought to light by a consideration of the kind of food to which they have restricted themselves since they have lived on reservations.
>
> There is no group of people with a higher incidence of tuberculosis than the non-citizen Indian. As wards of the Government they have been provided with money and land, but have in general shown little interest in agriculture. They have lived in idleness,

> and have derived their food supplies from the agency stores. In addition to muscle cuts of meat they have, therefore, taken large amounts of milled cereal products, syrup, molasses, sugar and canned foods, such as peas, corn and tomatoes. In other words, they have come to subsist essentially upon a milled cereal, sugar, tuber and meat diet. On such a regimen their teeth have rapidly become inferior and badly decayed. They suffer much from rheumatism and other troubles which result from local infections. Faulty dietary habits are in great measure to be incriminated for their susceptibility to tuberculosis.
>
> Other classes of Indians, who have become successful farmers, have not deteriorated as a result of contact with civilization, except in so far as they have suffered from alcohol and venereal infections. The non-citizen Indian has suffered, not because of contact with civilization, but because he has been forced into dietary habits which are faulty. (McCollum and Simmonds.)

In the days of their prime these people subsisted mainly on the wild game of virgin forest and prairie, regions in which the law of return operated fully.

For the last example I go back to the continent of Asia, to the people of rural China. Their diet is nearer to that of the Hunza than to any of the other examples we have looked at. Fruit, vegetables and sprouted grain are staples of both diets, but unlike the Hunza the principal cereal of the Chinese is rice, not wheat, and they also eat meat, birds, fish and eggs. They are in addition, as is well known, great tea drinkers. In common with the other four groups they eat the whole carcass and the whole grain or vegetable. In the matter of preparation they resemble the Hunza in that everything is eaten together. But are we justified in claiming that they are healthy?

Sooner or later all advocates of organic farming cite the Chinese, going so far as to call them the fathers of good husbandry. Their authority for doing so is almost always Professor King's famous book, *Farmers of Forty Centuries*. The critics of the 'organic school', however, challenge the accuracy of King's report. They say that he was only in the country for a few weeks, that the Chinese people as a whole have an abnormally high death rate, and that the whole country is riddled with disease, most of which is sewage borne because the peasants *fail* to compost their human wastes.

I have made great efforts to check these two opposing views. The truth seems to lie in the statement from Lord Northbourne's *Look to the Land*, that 'China presents remarkable contrasts between the best and the worst'. It is a vast country. Undoubtedly conditions are very bad indeed in some areas, particularly in the overcrowded cities, both as regards health and sewage disposal. But there seems equally little doubt that in certain rural areas composting of a very high order, amounting to a fine art, has been practised for centuries. But, however the overall picture should be painted, one fact seems indisputable, namely, that through the operation of the closed cycle (i.e. without the importation of chemical fertilizers) the soil of China has – despite periodic floods and famines – supported a huge population and a high culture for a period of 4000 years. For this reason, I feel quite justified, after having drawn attention to the other side of the picture, in once more quoting King. He was, after all, Chief of the Division of Soil Management in the US Department of Agriculture, and as such a qualified observer, recording facts as he found them. The references to the 'Medical Testament' contain an admirable summary of King's findings, and it is from that document that the following account is taken.

> King frequently inserts into his pages the cheerful, vigorous and healthy appearance of the Chinese lower classes, the Shanghai coolies, 'fully the equal of large Americans in frame, but without surplus flesh'; 'their great endurance', 'both sexes are agile, wiry, and strong' (Hong Kong); 'lithe, sinewy forms, bright eyes and cheerful faces, particularly among the women, young and old' (Canton); 'everywhere we went in China the labouring people appeared healthy and contented, and showed clearly that they were well nourished'. Cheerfulness is, indeed, common to those peasantries who follow the old agricultural ways.
>
> The average of seven Chinese holdings … indicates a maintenance capacity of 1783 people, 212 cattle or donkeys and 399 swine – 1995 consumers and 399 rough food transformers per square mile of farmland. These statements for China represent strictly rural populations. The rural population of the US in 1900 was placed at 61 per square mile of improved farm land and there were 30 horses and mules…
>
> They [the Chinese] have long realized that much time is required to transform organic matter into forms available for plant food, and, although they are the heaviest users in the world, the largest portion of this organic matter is predigested with soil or subsoil before it is applied to the fields. This is at an enormous cost of human time and labour, but it practically lengthens their growing season and enables them to adopt a system of multiple cropping which would not otherwise be possible. By planting in hills and rows with intertillage it is very common to see three crops growing upon the same field at one time, but in different stages of maturity – one nearly ready to harvest, one just coming up, and the third at the stage when it is drawing most heavily on the soil.

This disposes of the theory that increased production and heavy cropping have been responsible in this country for our diseases in crops. The Chinese have been cropping in this way for 40 centuries.

> The Chinese manure or compost is made of everything that can be collected which once got its life from the soil, directly or indirectly. They are mixed together until they form a black friable substance which is readily spread upon the fields. King describes a number of different processes he saw in different parts of China. One he describes as being carried out in compost pits at the edge of a canal, a process entailing 'tremendous labour of body and amount of forethought'. For months before his visit men had brought waste from the stables of Shanghai, a distance of 15 miles by water. This they had deposited upon the canal bank between layers of thin mud dipped from the canal, corresponding to silt collected in and taken from the recesses in the Hunza aqueducts, and left to ferment. The eight men at King's visit had nearly filled the compost pit with this stable refuse and

canal silt. The pit was in a field in which clover, with its peculiar power of taking nitrogen from the air, was in blossom. This was to be cut and piled to a height of five to eight feet upon the compost in the pit, and also saturated layer by layer with canal mud. It would then be allowed to ferment 20 to 30 days, until the juices set free had been absorbed by the winter compost beneath and until the time that the adjacent land had been made ready for the coming crop. The compost would then be distributed by the men over the field.

At another time he saw a compost pit within a village in which had been placed all the manure and waste of the households and streets, all stubble and waste roughage of the fields, all ashes not to be applied directly, mixed up with some soil. Sufficient water was added to keep the contents of the pit saturated and to promote their fermentation. All fibres of organic material have to be broken down, which may require working and reworking, with frequent additions of water and stirring for aeration. Finally the mixture becomes a rich complete fertilizer. It is then allowed to dry and is finely pulverized before it is spread upon the land.

Every foot of land, says King, is made to provide food, fuel, or fabric. 'The wastes of the body, of fuel and fabric, are taken back to the field; before doing so they are housed against waste from weather, intelligently compounded and patiently worked at through one, three or even six months, in order to bring them into the most efficient form to serve as manure for the soil or as feed for the crop.'

These then are the five peoples[7] which either still enjoy an exceptional measure of health, or else until very recently have done so. What have they in common?

Not race, for the groups include white, brown, red and yellow races.

Not climate – there could hardly be greater contrasts than between the plains and hills of rural China or the prairies of North America and the precipitous mountain crags of the northern provinces of India, or than between the frozen north and the luxuriant warmth of Tristan da Cunha.

Not diet – in the ordinary sense – for these range from the lacto-vegetarian diet of the Hunza to the almost purely carnivorous diet of the Eskimo, with almost every variant in between.

Not methods of preparing their food either, for though there are certain resemblances – as between Hunza and Chinese for example – no methods are common to all five.

In fact it seems clear that it is not in *kind* at all that we must look for our common factor, but in *quality*.

All five groups have good air to breathe, but that cannot by itself be the secret of their health, or our own hill and country dwellers would have health to compare with theirs, which, unfortunately, they have not.

The only discernible common factor, other than good air, seems to be that the diets of all five groups are 'whole' diets in the full sense of the word. That is to say: (a) every edible part contained in the diet is consumed; (b) in every case the foods are grown by a system of returning all the wastes of the entire community to the soil in which they are produced. For the sea, too, is a 'soil' in this sense, supporting its teeming population by means of the rule of return – the everlasting cycle of life and decay; (c) all the foods are natural unprocessed foods; and (d) the diets start before life begins; the parent is as healthy as the child.

There is a complete and continuous transference of health from a fertile soil, through plant and/or animal to man, and back to the soil again. The whole carcass, the whole grain, the whole fruit or vegetable, these things fresh from their source, and that source a fertile soil. Herein appears to lie the secret. If this be true, then the answer to our question, put at the beginning of this chapter, would appear to be that *any* diet is a health-promoting diet so long as it conforms to these three rules, and the first of these is a fertile soil.

> The importance of the method of culture of food is primary, radical, and fundamental in the matter of health. It exceeds all other aspects of nutrition – if, that is, one separates any aspect of what is a whole.

In the case of diets based on agriculture, such a view brings us back again to humus farming.

[It also served to emphasize the need for further investigation, and so led to the establishment of the Haughley Experiment.]

Notes

1 Unless otherwise stated, all quotations in this chapter are taken from this book.

2 When Dr Wrench wrote this, he was clearly unaware of the intensive study of health carried out by Drs G. Scott-Williamson and Innes Pearse known as 'The Peckham Experiment', and the definition of health that resulted from it. (See Part II, also new introduction to Part I.) So far, however, this extremely important and inspired piece of research remains the only investigation of its kind ever to have been undertaken.

3 'Staircase Farms of the Ancients', *National Geographic Magazine*, May 1916.

4 The capital of Hunza.

5 Ref. to 'Medical Testament'.

6 For further information on health conditions in Tristan da Cunha see Erling Christophersen, *Tristan da Cunha*, English translation published by Cassell, London, 1940.

7 It appears that to this list should be added the people of Prince Edward Island. See report by Dr Enid Charles in the Canadian *Journal of Economics and Political Science*, VIII, 1942.

12

The Nutrition Transition and its Health Implications in Lower-income Countries

Barry M. Popkin

Human history is characterized by a series of changes in diet and nutritional status. This pace of change has quickened considerably over the last three centuries.[1,2] Before that, major changes in diet and nutritional status occurred infrequently and one could argue that there were relatively few changes in diet for the first several million years of existence of the human race. This article focuses mainly on current stages in the nutrition transition. The concept of transitions or movement from one state or condition to another is used to capture the dynamic nature of diet, particularly large shifts in its overall structure. Many of the same factors that explain shifts in diet also explain those in physical activity and body composition. This work is based on the premise that the transition to the age of degenerative diseases is avoidable and that an understanding of the patterns and sources of change will serve as a basis for future interventions at the population level to lead to more healthful transitions.

A similar concept of transitions is embodied in the theory of the demographic transition – the shift from a pattern of high fertility and mortality (typical of less developed countries decades ago and of 18th-century Europe) to one of low fertility and mortality (typical of modern industrialized nations today). Even more directly relevant is the concept of the epidemiological transition, which focuses on changes in patterns of disease and causes of mortality. As first conceptualized by Omran,[3] the epidemiological transition moves from a pattern of a high prevalence of infectious diseases and malnutrition to one in which chronic and degenerative diseases predominate. Accompanying this progression from an earlier stage of pestilence, famine and poor environmental sanitation to the later stage of chronic and degenerative diseases strongly associated with life-style, is a major shift in age-specific mortality patterns and life expectancy. Both of these concepts of transitions share a focus on how populations move from one stage or condition to the next.

There have been large changes over time in diet and physical activity, especially their structure and overall composition. These changes are reflected in nutritional

Reprinted from Popkin B. 1998. The nutrition transition and its health implications in lower-income countries. *Public Health Nutrition* 1(1), 5–21.

outcomes such as stature and body composition. Furthermore, these changes are paralleled by changes in life-style and health status, as well as by major demographic and socioeconomic changes. For example, during the early stages of human evolution (from about 3 million to about 10 thousand years ago), human subsistence was based primarily on a pattern of gathering, scavenging and hunting. The diet these early humans consumed was varied, low in fat and high in fibre. Physical activity levels were high. In consequence, early *Homo sapien* hunter-gatherers tended to be taller and more robust, and suffered fewer nutritional deficiencies than humans who lived in settled communities during the period of early agriculture. These early agriculturalists' diet was much simpler and subject to tremendous fluctuations. After 10–12 thousand years of this second stage, the Industrial Revolution and a second agricultural revolution led to a considerable reduction of problems of famine, large shifts in diet and increased stature. This period was followed by a marked shift to the high-fat, refined carbohydrate, low-fibre diet which marks most high-income societies today. Also, an increase in obesity and all the degenerative diseases of Omran's final stage occurred. There is some indication that a new stage of behavioural change related to the reaction to man-made diseases is occurring in selected populations. These five periods are:

- the age of collecting food;
- the age of famine;
- the age of receding famine;
- the age of degenerative diseases;
- the age of behavioural change.

For this article, I focus mainly on the periods that relate to the circumstances most lower- and middle-income countries face – that is, a period where famine has receded and degenerative diseases are rapidly emerging.

The theory of the nutrition transition posits that these changes or stages relate to the complex interplay of changes in patterns of agricultural, health and socioeconomic factors, among others (for further detail see Popkin[1,2]). For this article, the major issues that are considered are demographic and economic changes.

The emergence in the last quarter of the 20th century of obesity as an epidemic among higher-income countries is acknowledged and has been of great concern in these countries. While the specific effects of the shifts in the patterns of diet and activity vary from population to population, both are important. We now face the emergence of obesity as a worldwide phenomenon affecting the rich and middle-income people alike in middle-income countries and also affecting countries previously considered to be poor. This emergence and prevalence of obesity, with all its related health complications, is felt to have major health complications. I note later in the article that this obesity epidemic has been linked in low- and middle-income countries with a rapid increase in the prevalence, as well as earlier age for the onset, of non-insulin-dependent diabetes mellitus (NIDDM). Other well-known complications of excess adiposity which are not discussed include coronary heart disease, many cancers and a large proportion of disabling osteoarthritis.

The attention given by the food and nutrition communities in countries such as China, Brazil and many lower-income countries has focused on problems of under-nutrition but information is presented here to indicate an emerging paradigm with obesity being the dominant problem or with an ever-increasing obesity problem coexisting with one of dietary deficit. Furthermore, these rapid shifts in obesity, caused by shifts in diet and activity, are linked with rapid increases in NIDDM and other related chronic diseases. This increase is found in countries whose populations are more genetically susceptible and in other nations. This combination of very rapid shifts in diet and activity and the emergence at very early stages of economic improvement of high rates of chronic disease forces us to focus attention on this topic.

After a brief introduction to the data and measures, the article first introduces the major underlying social and demographic changes, then the dietary and physical activity changes, followed by a discussion of the evidence of the obesity epidemic and NIDDM as it relates to this transition.

Methods

Data

Data came from a large number of sources, mainly nationally representative or large nationwide surveys. In addition I use national data sets such as food balance sheets and national income accounts.

A thorough presentation is made of the China Health and Nutrition Survey (CHNS), an ongoing, longitudinal survey of eight provinces in China. A multistage, random, cluster sampling procedure was used to draw the sample from each province. Additional detail on the research design of this survey is presented elsewhere.[5]

For some of the information on obesity patterns and trends, the focus is mainly on larger and more representative samples of adults. Our selection criteria for presenting data from other surveys was size, sampling design and geographic area. If a study was representative of a region or country, it was always used. If it came from a region with few studies and did not fit the criteria of national representativeness, I used it if the sample size was large and it seemed reasonably representative. Note that I use the term region only to fit a cluster of countries and not an area within a country.

National food consumption data came from the Food and Agriculture Organization of the United Nations (FAO) food balance sheets for the period 1962–1990, now available in the FAOSTAT database.[6] Data on food availability are combined to express in percentage terms daily energy from macronutrients, with the official estimates of gross national product (GNP), as established by the World Bank.

Measures

For the national food consumption and economic pattern analysis, GNP per capita was expressed in 1993 American dollars to allow for an easier comparison of the results. Regression analyses were used to relate dietary data (the proportion of energy from vegetable and animal fats, carbohydrates, caloric sweeteners and protein) for those countries for which full sets of data were available in 1962 and in 1990 to the logarithm of per capita GNP. This research used all countries for which both sets of data were available – 98 in 1962 and 133 in 1990. These results were not changed when looking only at a set of countries with full sets of data in both 1962 and 1990.

The regression analysis also included an urbanization variable. Although GNP and the extent of urbanization were closely linked before World War II, this is clearly no longer the case and many lower-income countries now experience very high rates of urbanization. Throughout the text the term lower income is used to describe a quite heterogeneous group of nations. In addition, the term less and more developed nation is used in this article interchangeably with lower income. In the regression analyses, the percentage of energy from each macronutrient was regressed on GNP per capita, the proportion of the population residing in urban areas that year, and an interaction term between GNP per capita and the proportion of urban residents. All variables in this regression were highly significant.

Body mass index (BMI) is the standard population-based measure of overweight and obesity status. For adults, the cut-offs used to delineate obesity are less than 18.5 for thinness (chronic energy deficiency), 18.5 to 24.99 for normal, 25.0–29.99 for overweight grade I, 30.0–39.99 for overweight grade II, and 40.0 and above for overweight grade III.[7] For this article, grades II and III are combined.

Factors Underlying the Nutrition Transition

It is useful to consider demographics and economics, two of the propositions that affect diet and activity which are changing very rapidly.

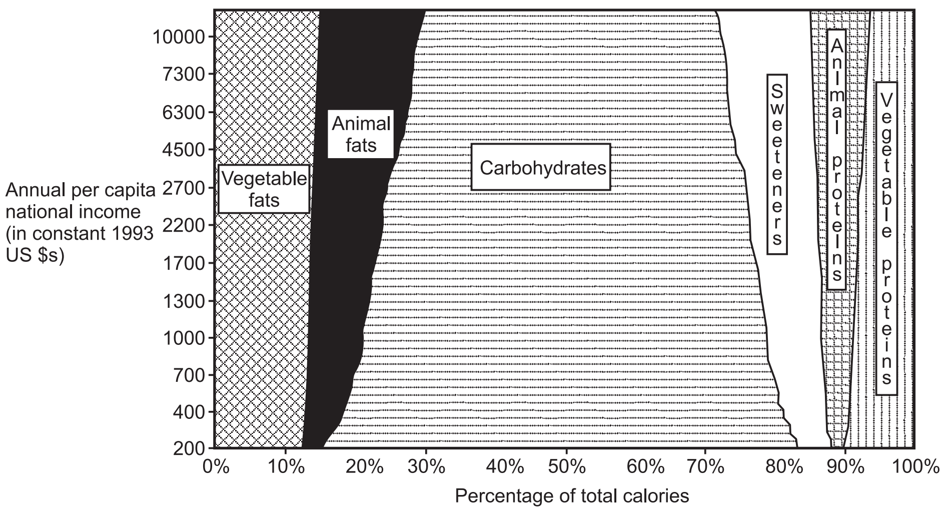
Proposition 1: Major shifts in population growth, age structure and spatial distribution are closely associated with nutritional trends and dietary change

No attempt is made here to address all aspects of this proposition but rather to focus in some detail on one of the most powerful sets of shifts linked with demographic change – rapid urbanization. Evidence indicates a most pronounced association of urbanization with the shifts in diet and activity and body composition.

People living in urban areas consume diets distinctly different from those of their rural counterparts. City dwellers have led the movement from the pattern of famine to the patterns of receding famine and the rise of degenerative disease. Compared with rural diets, urban diets show trends toward consumption of the following:

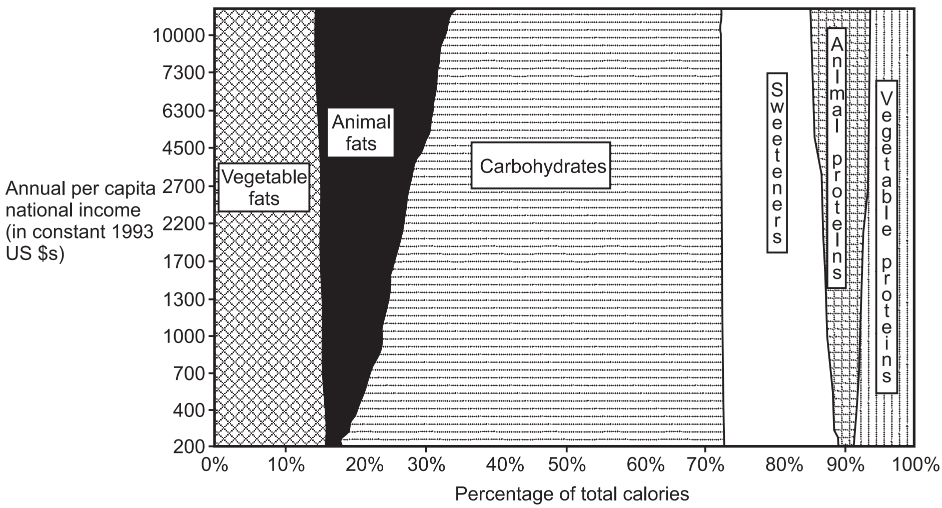
- superior grains (e.g. rice or wheat, rather than corn or millet);
- more milled and polished grains (e.g. rice, wheat);
- food higher in fat;
- more animal products;
- more sugar;
- more food either prepared away from the home or processed.

The potential impact of urbanization on diet structure is shown by this regression model. The model used FAO food balance sheets and World Bank economic indicators data for 1990. The regression relating GNP per capita to the outcomes of energy from each food source includes as a covariate the proportion of residents residing in urban areas and an interaction between the proportion urban and GNP per capita. For the purposes of clarification of the impact of shifts in urbanization, the results of those regressions were used to predict (simulate) the diet structure with the proportion of urban residents worldwide at either 25 or 75 per cent. As shown in Figures 12.1 and 12.2, for higher rates of urbanization, the simulation developed from our model predicts a substantial increase in the consumption of sweeteners and fats. The clear implication is that a shift from 25 to 75 per cent



Source: Food balance data from the FAOUN; GNP data from the World Bank; regression work by UNC-CH

Figure 12.1 *Relationship between the proportion of energy from each food source and gross national product per capita with the proportion of the population residing in urban areas placed at 25 per cent, 1990*



Source: Food balance data from the FAOUN; GNP data from the World Bank; regression work by UNC-CH

Figure 12.2 *Relationship between the proportion of energy from each food source and gross national product per capita with the proportion of the population residing in urban areas placed at 75 per cent, 1990*

urban population in very low-income countries would be associated with an added four percentage points total energy from fat and an additional 12 percentage points energy from sweeteners.

When analysis is undertaken at the country level, it is clear that these contrasts between urban and rural eating patterns are more marked in lower-income than in higher-income countries. In higher-income countries, market penetration into rural areas is common, and nationally integrated food distribution systems exist. Nevertheless, higher-income countries show important urban–rural differences in eating patterns, especially in consumption of food prepared away from home[8] and responsiveness to information and the influences of mass media. Even in higher-income countries, large differences between urban and suburban food and labour markets, in combination with other factors related to residence, result in distinct dietary and nutritional status patterns.

Key factors responsible for urban–rural differences in dietary intake and resulting differences in nutritional status include:

- better transportation and marketing systems in urban areas that provide greater availability of food during periods of seasonal shortage;
- greater penetration of marketing activities of the processed commercial food sector into the denser urban markets;
- greater heterogeneity of urban populations with respect to dietary pattern;

- different occupational patterns, characterized in urban areas of reduced compatibility of jobs with home food preparation and child and elder care;
- different household structures related to a wide range of economic and social factors;
- different disease and health service use patterns.

(For a more detailed review of dietary aspects of urbanization, see Popkin and Bisgrove.[9])

Key dimensions of world urbanization

Several major demographic shifts began in the post-World War II period and continue unabated and have even accelerated in some regions. One is the vast increase in the proportion of persons who reside in urban areas. A second is urban agglomeration. A third is the shift of poverty toward the urban areas, particularly toward squatter and slum areas.

Proportion living in cities

Urban growth was relatively modest before the Industrial Revolution. Rapid urban development first occurred in the higher-income countries; now, lower-income countries are undergoing even more rapid urbanization. In the last half of the 20th century, urbanization resulting from migration and natural increase has become a dominant factor in all regions and shows no signs of abating. The proportion of persons living in urban areas in developed and developing countries has changed significantly since 1950. Table 12.1 shows that the higher-income world is comprised predominantly of urban residents today which is not the case for the less developed and poorest least developed countries.[10] Nevertheless, by 2025 urban residency will be the common form of residence throughout all but the poorest African countries.

The continuation of the migration of rural residents to urban areas more than offsets the much lower urban fertility rate and leads to the quite different patterns of growth in urban and rural areas. Table 12.2 shows that these patterns accelerate in the next century.

Table 12.1 *Urban population, 1970, 1994 and 2025*

	Urban population (millions)			*Urban share (percentage)*		
Region	*1970*	*1994*	*2025*	*1970*	*1994*	*2025*
World	1353	2521	5065	36.6	44.8	61.1
Less developed regions	676	1653	4025	25.1	37	57
Least developed countries	38	122	506	12.6	21.9	43.5
More developed regions	677	868	1040	67.5	74.7	84

Source: United Nations: Population Division, 1995[10]

Table 12.2 *Average annual growth rate of urban and rural population, less developed regions (percentage)*

Region	*1965–70*	*1990–95*	*2020–25*
Less developed region			
urban	3.58	3.51	2.33
rural	2.18	0.96	–0.28
Africa			
urban	4.64	4.38	3.34
rural	1.98	2.03	0.72
Asia			
urban	3.28	3.68	2.31
rural	2.34	0.81	–0.57
Latin America			
urban	3.97	2.6	1.26
rural	0.81	–0.2	–0.61
Oceania			
urban	7.26	3.13	3.32
rural	1.62	1.9	0.22

Source: United Nations: Population Division, 1995[10]

Concentrated population growth

Urban growth, particularly in lower-income countries, has been skewed towards a few larger cities, often called urban conglomerates. These cities of 5–27 million dominate many countries and are growing much faster in the less developed than in the more developed regions of the world. Nevertheless, in the lower-income world, more than half of the urban residents reside in smaller and medium sized cities with populations less than 500,000.[10] As is seen in Table 12.3, the most explosive growth of these mega-cities is in Asia.

Table 12.3 *Mega-cities, number 1970–2015*

Region	*1970*	*1994*	*2000*	*2015*
World	11	22	25	33
Less developed region	5	16	19	27
Africa	0	2	2	3
Asia	2	10	12	19
Latin America	3	4	5	5
More developed regions	6	6	6	6

Note: Mega-cities have 8 or more million residents.

Source: United Nations: Population Division, 1995[10]

Shift in the proportion of poor to the cities

Concomitant with increased concentration of the population in urban areas is a dramatic shift in the proportion of poor people living in cities. In absolute and relative terms, the majority of the poor of the lower-income world live in cities. By the year 2000, it is estimated that 57 per cent of the poor will live in urban areas.[9,11] Estimates of the distribution of the poor are rare. The one used by the World Bank was the subject of extensive research. While it is old, it is felt to be more carefully prepared than many more current projections. However, it is estimated that a majority will reside in dense slums or makeshift dense squatter settlements. At the same time a disproportionate share of the upper income and upper-middle income population also lives in urban areas.

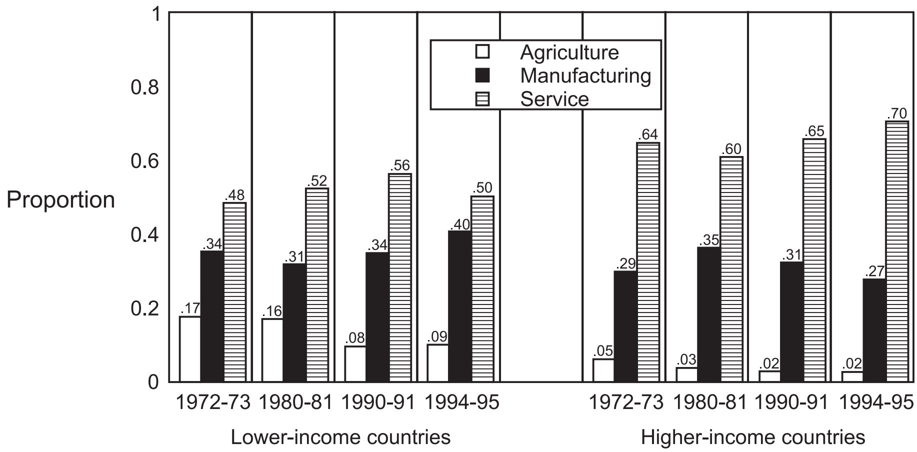
Migration

An important dimension of urban growth is its associated pattern of migration. Migration from rural areas to cities (and to a lesser extent from small to larger cities) and international migration have affected diet profoundly. For example, populations of Samoans who moved to San Francisco, Polynesians and Maori who moved to New Zealand, Japanese who moved to the US and Yemenite Jews who moved to Israel all showed large changes in diet, followed by large increases in diet-related chronic diseases.[12–15]

In other research, a national survey of American adolescents examines the effects of generation of birth in the US. In this work, first-generation Americans are defined as those born outside the US. It was found that there is more than a doubling of obesity of Asian-American and Hispanic adolescents between the first-generation and second-generation Americans (those born in the US). With about 3400 Hispanics and over 2000 Asian-Americans in the nationally representative sample, the likelihood of being obese increased from 23.2 to 32.6 per cent among Hispanics going from the first to second generation and 10.7 to 24.6 per cent for Asian-Americans. The 85th percentile reference[7] was used for obesity.[16] As discussed below in reference to the Barker metabolic programming hypothesis,[17,18] it is possible that the increased obesity in these immigrants is explained partially by fetal and infant nutrition insults: however, we feel that there is potential for an independent environmental component which may explain this American experience.

Proposition 2: Changes in income, patterns of work and leisure activities and related socioeconomic shifts lead to changes in women's roles and shifts in dietary and activity patterns

A major change in economic structure associated with the nutrition transition is the shift away from a pre-industrial agrarian economy and towards increasing industrialization. This transformation then accelerates; the service sector grows



Source: World Bank, 53 countries, over a 23-year period

Figure 12.3 *Shifts in the distribition of occupation, 1972–1995*

rapidly, industrial production is dominated by capital-intensive processes and time-allocation patterns change dramatically. Associated socioeconomic changes especially important in the nutrition transition phenomenon are (a) changes in the role of women (especially with respect to patterns of time allocation); (b) changes in income patterns; (c) changes in household food-preparation technology; (d) changes in food production and processing technology; and (e) changes in family and household composition.

The sectoral distribution of the labour force towards industry and service has accelerated around the world. Figure 12.3 presents data on this pattern for higher- and lower-income countries. It shows for all lower-income countries a pronounced move away from agriculture and towards manufacturing and service employment. As has often been shown, the most labour-intensive agricultural work requires the greatest amount of energy expenditure. One of the most inexorable shifts with modernization and industrialization is the reduced use of human energy to produce more capital-intensive manufacturing and goods and services. The result is obviously a marked shift in activity patterns at work, a trend particularly associated with our shift into increasingly capital-intensive production and increasingly sedentary manufacturing, service and commercial work. This within-occupation shift in energy expenditure cannot readily be shown with national data. It requires individual level information.

Unfortunately, few longitudinal studies attempt to measure physical activity and energy expenditures. One quite simple measure of overall activity has been collected in each survey from 16,000 Chinese as part of the CHNS. Table 12.4 shows the shifts in the proportion of Chinese adults involved in low levels of physical activity at work. In particular, urban residents in all income groups were more likely in 1993 to have adopted a more sedentary activity pattern. Elsewhere,

Table 12.4 *Distribution of physical activity of Chinese aged 20–45 years, by thirds of household income and residence, CHNS 1989, 1991 and 1993*

	Household income per capita thirds								
	Low			Middle			High		
	1989	1991	1993	1989	1991	1993	1989	1991	1993
Urban residence									
lowest level activity	23.7[b,]**	34.3[b]	42.6	35.5*	45.4	42.8	44.5*	58.3	55.5[a]
middle level activity	49.6[b,]*	30.1	30.2	46.1*	39.7[a]	40.6	48.0*	34.5	32.0[a]
highest level activity	26.7[b]	35.6[b,]*	27.2	18.4	14.9	16.6	7.5	7.2	12.5[a,]*
Rural residence									
lowest level activity (%)	15.3*	3.9[b]	4.8[b]	16.2*	12.3	12.6	23.7[a]	24.8	19.8
middle level activity (%)	22.2[b,]**	5.3[b]	7.9[b]	28.9*	14.1	13.3	35.2*	24	26.8*
highest level activity (%)	62.5[b,]**	90.8[b]	87.3[b]	54.9*	73.6	74.1	41.1*	51.2	53.4

[a] The proportion differs significantly from middle- and high-income groups within same year ($P < 0.05$).
[b] The proportion differs significantly among three income groups within same year ($P < 0.05$).
* The proportion differs significantly from corresponding value in other 2 years ($P < 0.05$).
** The proportion differs significantly from corresponding value among the 3 years ($P < 0.05$).

this is linked with significant increases in BMI and obesity.[19] In contrast, this pattern was not seen in the rural areas. In fact, rural residents, particularly low-income ones, showed a significant change from low and moderate activity patterns towards a high physical activity pattern and related to that, an increase in chronic energy deficiency measured by a BMI below 18.5.

Related to the effect of industrialization and modernization on market production is a similar shift in time allocation and physical effort in home and leisure activities. Since the discovery of fire, a key thrust in the continuing development of household technology for processing and storing food has been to save time and enhance the quality of life. In the last century, the evolution of household technology seems to have accelerated. In food-preparation technology, recent developments include efficient ways to prepare and store food (canning, refrigeration, freezing, radiation treatment, packaging, etc.); food processing with tools such as electric mixers and food processors; and cooking with pressure cookers, cookware made with improved metals and alloys, metal stoves using various fossil fuels, and microwave ovens.

These food-preparation technologies, together with home electrification, washing machines and clothes dryers, vacuum cleaners, piped water, and so forth have transformed home production from a time-consuming, often back-breaking, full-time occupation for peasant or working-class women. Although home production still requires time and energy, purchased technology where accessible can help save time for those who engage in home production activities. One way to see how these household technologies have made transformations in a society is to examine the studies of the introduction of electricity to agricultural societies, which show large, rapid transitions in the use of time, the roles of various household members and other social factors.[20] Herrin's classic study on the impact of electrification on the lives of families in poorer regions has demonstrated the profound shift in the use of time related to the use of electricity.

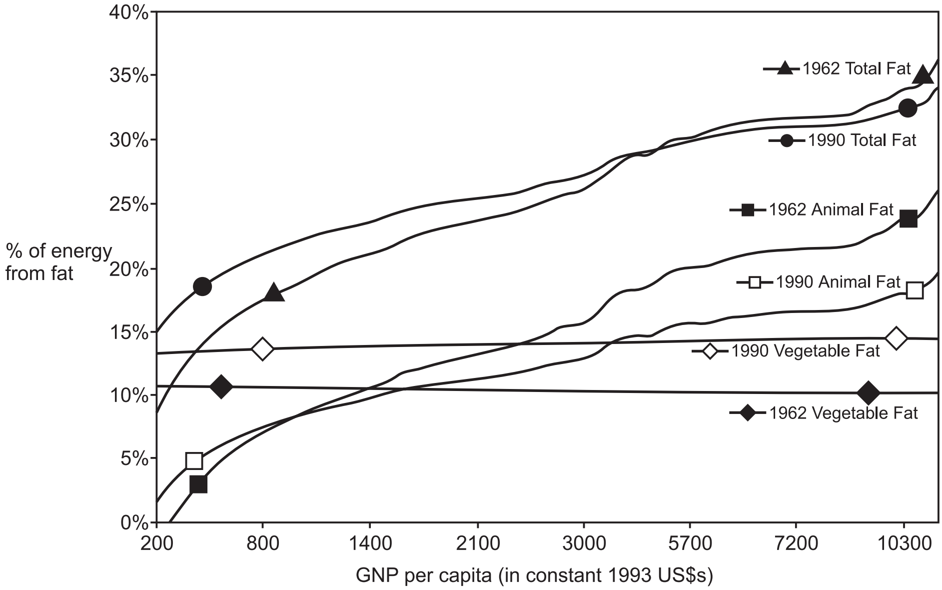
Possibly an even more astounding shift has come in leisure activities. In the past, leisure activities for children often meant active play, but leisure today may mean a quite sedentary activity such as watching television or playing a computer game. Documentation of such patterns across the lower-income world is not available in terms of time spent and the shift in activities. This area needs greater focus.

Income patterns

Income is an important element in the nutrition transition because it measures control over the flow of goods and services. In other words, income allows one to purchase goods or services that can affect diet and activity, and nutritional status. Three key issues relating income to nutrition are (a) the effect of income changes on dietary structure; (b) the effect of income changes on the amount of energy, protein and fat consumed; and (c) the effect of change in the structure of the economy, particularly the change to commercial agriculture on the nutritional status and diet of subsistence agriculturalists. The effect of income in purchasing the assets and technologies that in turn affect time use, diet and activity patterns noted above, is equally important but not discussed here.

As Figures 12.1 and 12.2 show, increasing income is strongly associated with changes in the proportion of energy in the diet from various sources. What has been shown more recently, however, is that the strength of the income and dietary fat relationships have been somewhat uncoupled at the national level. Figure 12.4 presents a regression of the proportion of total, vegetable and animal fat on GNP. The results show a strong flattening of the relationship and a shift towards much higher consumption of dietary fat among poor nations than was previously known. In other words, lower-income countries are now able to afford the types of higher-fat diets that previously were accessible only to middle-income countries.

These relationships between income and diet noted in Figures 12.2 and 12.3 have an important culture-specific component. The responsiveness of dietary total energy, total and saturated fat, and other macro- and micro-nutrients to income change depends upon the nature of the demand for particular foods and by overall eating patterns. For example, in the Philippines, the coconut palm is a major source of cooking oil, and income increases are associated with increased away-from-home consumption of foods that are frequently fried; thus, saturated fat and total fat consumption are highly responsive to income increases, particularly those accruing to women.[21,22] Similarly, in China, pork consumption is highly responsive to increases in income, which thus result in large increases in the proportion of energy from fat.[5,23,24] In contrast, where income increases are spent on more elaborate packaging and processing or higher quality of specific foods, rather than



Source: Regressions run with food balance data from FAOUN; GNP data from the World Bank

Figure 12.4 *Relationship between the percentage of energy from fat and GNP per capita, 1962 and 1990*

larger quantities of food or shifts in the types of foods, changes in income will have less effect on dietary structure.

A related point is that while the GNP–fat intake relationship has flattened, it is shown elsewhere that there remain in all countries important relationships between income and fat consumption at the individual and household level.[25]

A second apparent relationship between income and diet is that as income increases (beyond the point where total food energy needs are met), people spend more per food item,[26] partly to obtain higher quality. As many authors have shown, food demand is much more price- and income-elastic among the poor than among higher-income groups.[26,27] Changes in diet with increased income also relate to the reduced time needed to consume higher quality and higher priced goods that have undergone more processing before purchase.[28]

Income has been and will continue to be an important identifier of groups at risk of either nutritional deficiency or nutritional excess. Income and more complex measures of socioeconomic status that incorporate other dimensions of social and economic well-being, such as education, asset ownership, occupation and various more qualitative measures of 'status', are useful in identifying problems of deficit in all societies and problems of excess associated with the pattern of degenerative disease.

For lower-income countries, a crucial dimension of the relationship between socioeconomic status and nutrition is the distribution of chronic disease risk factors by income group. In higher-income countries, the poor are far more likely to suffer from obesity, NIDDM, coronary heart disease (CHD), and other chronic diseases.[29,30] This has not been found in lower-income countries, although this pattern is slowly changing. For instance, a recent World Bank study on adult health in Brazil[31] indicates that where income constraints among the poor are not too severe, many risk factors for cardiovascular disease will likely be greater among the poor than among the rich. This inverse income-obesity relationship is beginning to be found in larger sub-population groups in Brazil[2] and in other Latin American countries.[32] Within the next 10–20 years, in most of Latin America and many parts of Asia, obesity and NIDDM will become problems of poverty. There are already indications that this is occurring in South Africa.[33] The rapid increases in obesity found in lower-income countries are discussed below together with the consequences of this change.

Intermediate Factors: Diet and Physical Activity

While nutrition researchers have typically focused on the study of diet, it is no longer the only issue of concern. Diet and physical activity are intertwined, and interactions between energy intakes and expenditures are amenable to intervention. It may very well be that the rapid reduction in physical activity rather than diet explains as much or more of the increased obesity facing lower and transitional income countries. Research is needed to quantify the relative impact of each set of factors.

Physical activity

As noted above, the remarkable shifts in occupations and in travel to work along with changes in the nature of home production and leisure activity have had profound effects on activity patterns throughout the world. Few studies have measured this shift in activity and energy expenditures. One quite simple measure of overall activity has been collected in each survey from 16,000 Chinese as part of the CHNS. It has been reported elsewhere that a remarkable shift in activity patterns for adult Chinese occurred between 1989 and 1993 as shown in Table 12.4.[2]

Structure of diet

Most researchers have focused on the shift from diets high in complex carbohydrates and fibre to those with a higher proportion of fats, saturated fats and sweeteners. But underlying these broad patterns are major shifts in the type of staples selected, and in the overall diversity of the diet. In most countries one of the first shifts is from lower quality or inferior staples to those deemed to be of higher quality.

In one country lower quality might be millet, in another it might be sorghum or cassava. This shift is accompanied or followed rapidly by the decline in the proportion of energy from these basic staples.

The work undertaken to date on this nutrition transition seems to show remarkable congruity in the broad shifts in diet and in the ever-increasing shift towards higher-fat diets in all regions of the world. Little has been done systematically to lay out the role of the array of socioeconomic, technological and other factors that explain this shift. The best work has been done on the role of urban residence (e.g. the work of Bourne et al[34,35]) and its relationship to eating habits.

The shifts in the proportion of energy from fat, protein and carbohydrates provide some sense of the broader shift. At the country and individual level, studies have been conducted in China[5] and Brazil[36] to provide examples and present information from a selected set of food groups from China to highlight the food shifts. As shown in Table 12.5, there is a marked shift away from grains and tubers towards fats, meat and eggs amongst other things. In addition, there are marked differences in the diets of lower-, middle- and higher-income thirds in this country with a much smaller income distribution than is found in many countries. Table 12.5(a) presents the average intake for each food for low-, middle- and upper-income adults in 1989 and then presents the change for these adults over a four-year period. Table 12.5(b) presents the proportion who consume each of these foods and the shift in the proportion (percentage points) who consumed them between 1989 and 1993. Essentially this table shows that lower-income adults consume more carbohydrates and vegetables and less meat, eggs and oils. Moreover, over time there is a pronounced trend towards a reduced consumption of grains, tubers and corn products, and an increase in consumption of meat and meat products, eggs and oils.

Table 12.5(b) shows that while per capita intake is changing markedly towards higher intake of fats, eggs and meats, a greater proportion of individuals is consuming many grain and vegetable products. In this table, a food grouping system is used that was developed to separate the Chinese food composition table into 33 distinct food groups. Then the number consumed by each person is added up to present mean intake and the proportion with high and low numbers of food groups consumed. It is noteworthy that there is a marked increase in diversity of the Chinese diet, but the total amount consumed of many starchy staples and other higher fibre and nutrient-rich plant-based foods is being rapidly reduced.

It is essential not to ignore the benefits of this shift. The new Chinese diet is more diverse and linked to reduced under-nutrition. This trend towards a more diverse diet is seen systematically in most countries in Asia, Africa and Latin America. The diet of grains and tubers mixed with small amounts of condiments, possibly a few legumes and a small amount of meat/fish/poultry is clearly not the diet desired by the population. Using our China-UNC-CH food grouping system of 40 groups, with alcohol and condiments removed, the shift towards a more diverse diet is seen by examining the move from a very low diversity to a highly diversified diet in Table 12.6. Over time, the proportion of Chinese of all income groups who

Table 12.5(a) *Changes in Chinese food consumption categorized by income group*

	Bottom third		*Middle third*		*High third*	
	1989 (g/capita/day)	*Change from 1989 to 1993*	*1989 (g/capita/day)*	*Change from 1989 to 1993*	*1989 (g/capita/day)*	*Change from 1989 to 1993*
Whole steamed/boiled rice	317.0	–40.4	322.2	–10.6	287.3	–10.3
Wheat flour	176.2	5.6	145.4	–39.7	151.2	–72.5
Fresh and dried corn	69.4	–38.4	28.0	–9.8	20.4	–10.3
Coarse grains	29.7	–14.7	10.6	–2.9	6.6	2.2
Legumes	12.7	–1.3	10.9	–2.5	12.1	–2.2
Tofu	23.0	–3.2	28.5	–6.0	23.7	1.3
Tofu products	11.7	–1.2	13.1	1.3	16.9	–0.6
Starchy roots	133.0	–77.5	63.0	–27.4	41.8	–13.6
Carotene-rich vegetables	78.8	–2.6	82.6	9.9	73.4	12.7
Other vegetables	318.7	–55.6	264.4	–1.9	230.3	7.7
Low-fat red meat/dishes	3.8	2.2	6.1	5.2	8.9	10.2
High-fat red meat/dishes	29.1	2.0	44.6	5.3	53.8	17.1
Poultry and game	4.2	–0.6	6.4	3.0	7.9	4.6
Meat products	2.2	–0.7	2.1	0.7	3.4	–0.1
Organ meats	2.2	–0.2	3.3	0.5	4.3	0.2
Eggs and egg products	7.1	2.8	9.2	6.0	16.3	4.2
Plant oils	12.9	12.6	15.5	16.1	17.3	19.2

Table 12.5(b) *Changes in the proportion of Chinese consuming each food group categorized by income group*

	Bottom third		*Middle third*		*High third*	
	1989 (% consuming)	*Change in % from 1989 to 1993*	*1989 (% consuming)*	*Change in % from 1989 to 1993*	*1989 (% consuming)*	*Change in % from 1989 to 1993*
Whole steamed/boiled rice	72.4	1.3	84.3	2.5	90.7	0.9
Wheat flour	45.7	–0.8	57.5	–18.4	67.6	–30.2
Fresh and dried corn	31.2	–9.5	17.6	–3.1	16.1	–5.3
Coarse grains	12.9	–2.7	9.7	–1.0	9.4	1.2
Legumes	18.9	–3.6	18.7	–3.9	19.6	–4.9
Tofu	25.5	1.1	34.1	–0.0	33.3	3.3
Tofu products	22.0	2.1	28.0	3.3	35.7	0.4
Starchy roots	38.6	–0.5	34.6	–1.8	32.7	–3.0
Carotene-rich vegetables	42.4	6.0	56.1	3.9	60.3	8.9
Other vegetables	92.3	4.0	92.7	3.2	95.7	1.2
Low-fat red meat/dishes	6.6	2.5	13.2	3.9	18.6	8.5
High-fat red meat/dishes	36.8	7.0	57.5	3.5	69.1	6.7
Poultry and game	5.8	0.8	10.0	3.8	14.1	5.8
Meat products	3.8	–0.0	4.3	1.1	6.9	–0.3
Organ meats	4.4	–0.4	7.7	1.4	11.0	0.4
Eggs and egg products	14.9	7.8	24.5	10.1	40.9	3.7
Plant oils	56.6	30.6	63.3	24.3	69.7	19.7

Table 12.6 *Diversity in the Chinese diet: the number of food groups consumed by Chinese adults aged 20–45 years, CHNS 1989–1993*

Year		*Income thirds*		
	Low	*Medium*	*High*	*Total*
1989 Sample size	1892	1889	1834	5615
Mean score	6.5	7.7	9	7.7
Score < 5(%)	17.1	6.8	3.5	9.2
Score > 10 (%)	4.4	12.1	29.6	15.2
1991 Sample size	1855	1918	1839	5612
Mean score	7.4	8.1	9.6	8.2
Score < 5(%)	10.7	6.6	1.8	6.4
Score > 10 (%)	5.9	17.8	35.2	19.5
1993 Sample size	1749	1814	1680	5243
Mean score	7.3	8.5	9.7	8.5
Score < 5(%)	6.6	2.8	1.2	3.5
Score > 10 (%)	9	21.8	36	22

Note: The range of diversity scores is 1–33.

consume very few food groups (five was selected) has declined while those who consume more than ten increases.

Body Composition

One consequence of this nutrition transition has been a decline in under-nutrition accompanied with a most rapid increase in obesity. In all age groups, there is evidence of a rapid increase in obesity and also an array of dietary excess and body composition-related health outcomes such as glucose intolerance and diabetes. Monteiro et al[36,37] (also Monteiro, forthcoming[38]) has documented this shift away from undernutrition most clearly for Brazil.

Programming – a potential link

David Barker and colleagues at the University of Southampton[17,18] have brought into the mainstream the notion of metabolic programming: that early insults operating at a critical period in development result in long-term changes in the structure or function of an organism. In the case of obesity, the hypothesis is that fetal growth retardation results in metabolic changes that are adaptive under nutritionally stressful circumstances *in utero*. A similar argument can be made for postnatal growth retardation manifested as stunting. As the child grows, the metabolic efficiencies that served well in conditions of under-nutrition become maladaptive with over-nutrition, leading to the development of abnormal lipid profiles, altered glucose and insulin metabolism, and obesity.

One reason why the programming hypothesis is so powerful for health relates to its effects on the distribution of obesity. There appears to be the potential for increased visceral adiposity. That is, the literature that has linked metabolic programming with obesity has also shown a greater likelihood of increased waist–hip ratio and other measures of visceral or abdominal obesity. A separate literature has demonstrated that increased visceral adiposity is linked with NIDDM, CHD and stroke.[39]

In other work, four nationally representative samples of children (or a nationwide one for China) show that indeed there is potential that this hypothesis represents a critical link between the foetal and infant insults associated with underdevelopment and the transition towards a lower activity/higher-fat diet associated with the nutrition transition.[40] In fact, without this transition in diet and activity it would not be possible for the biological effects associated with metabolic programming to lead to abnormal lipid profiles or obesity.

The high level of child obesity in China, Russia and South Africa in comparison with National Health and Nutritional Examination Survey (NHANES) III is discussed elsewhere.[40] The really solid causal work on this metabolic programming relationship and any mechanisms that might explain it or Barker's hypothesis is either in process or remains to be undertaken. If this most significant relationship, often termed the programming effect, is as important as the early descriptive results indicate, then this represents an ominous warning regarding infant health. Low-income countries with high fetal and infant malnutrition rates, must make particularly rapid programme and policy shifts to address these additional undesirable consequences of the nutrition transition.[41]

As issues of obesity and later NIDDM are presented below, it is important for the reader to be aware of this hypothesis and its potential for explaining, among other issues, the higher NIDDM levels found in newer urban residents in black South Africa and the parts of the increases in NIDDM elsewhere in Latin America, Asia and Africa.

Prevalence in Lower- and Middle-income Countries

Limited information is presented on obesity patterns and trends in lower-income countries. The focus is on a few cases and the reader is directed to a more thorough review for more detail. Data from Asia and Latin America for adults are presented in Figures 12.5 and 12.6. We look at three measures of obesity, grade I, grades II and above, and the total of all grades. The ages for these data vary slightly but generally are presented for age 20 years and above.

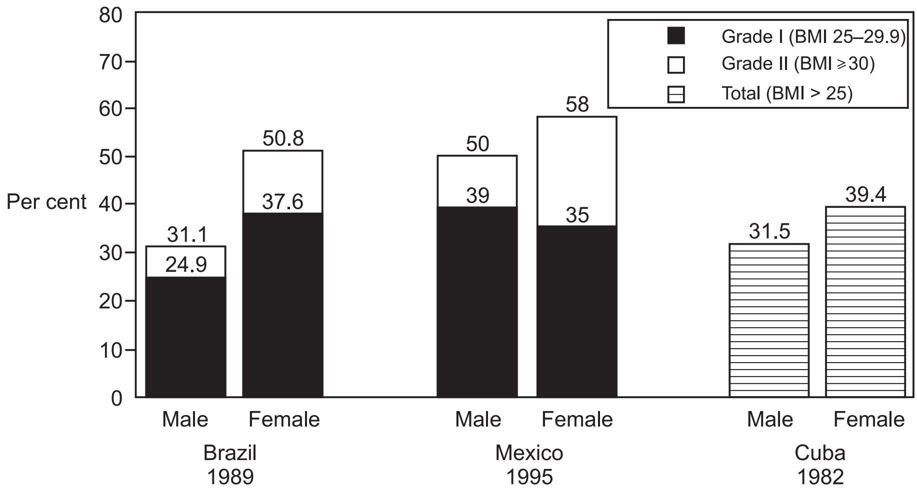


Figure 12.5 *Obesity patterns in Latin America*

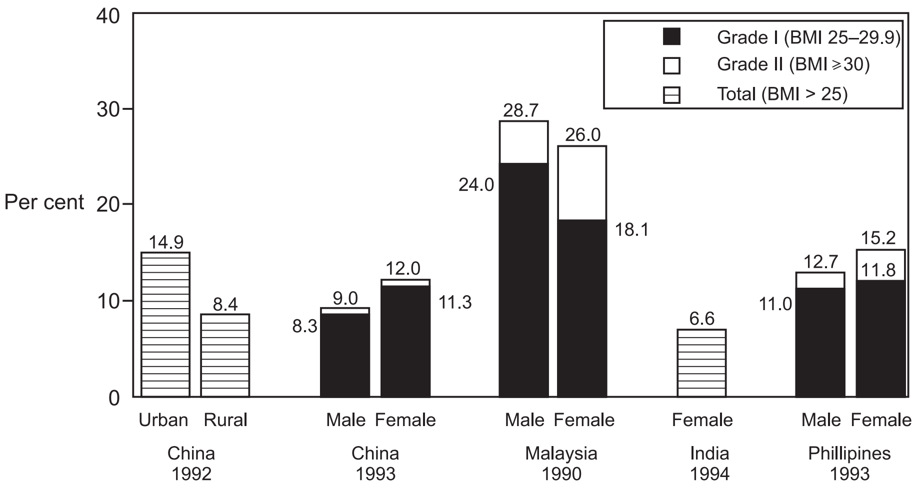


Figure 12.6 *Obesity patterns in Asia*

Latin America

When looking at grades I and II and above obesity measures for Latin America, levels of obesity in the 30 and higher range are found in Brazil, Mexico and Cuba. The range is lower in other South American countries but there is no nationally representative survey for most countries. In Brazil and Cuba, women have higher levels of overweight and obesity than men but this is reversed in one survey in Mexico conducted in 1995. There are few data available in terms of large-scale surveys in the Caribbean; however, other studies and the Cuban data presented here indicate that the Caribbean nations have very high levels of obesity.[42]

Asia

There is still much less obesity in the largest two countries in Asia, China and India, but levels are higher in other countries. For instance, total grade I and above levels are between 25 and 30 per cent for Malaysia, and 13 and 19 per cent for the Philippines. The exceptions are the Central Asian countries such as Kyrgyzstan that were members of the Soviet Union prior to 1992. Grade I overweight status is currently the major problem in Asia except for Malaysia. There is no clear gender pattern to levels of obesity in Asia.

Trends

There are a small number of lower- and middle-income countries for which we have excellent data on trends in body composition. Nationally representative or large nationwide data sets are available for Brazil in Latin America; China and India in Asia; Mauritius in Africa; Nauru and Western Samoa in the South Pacific; and Russia. These provide some sense of trends in adult obesity. Figure 12.7 shows the trends for the few countries for which there are nationally representative data. We created ten-year changes in the percentage points of obesity for each. Much greater detail of these obesity patterns and trends are presented elsewhere.[43]

Brazil

Monteiro and his colleagues[36] have shown that during a 15-year period, the proportion of grade II and above overweight adult males almost doubled (5.7–9.6 per cent). For females of reproductive age the proportion of grade II obesity increased

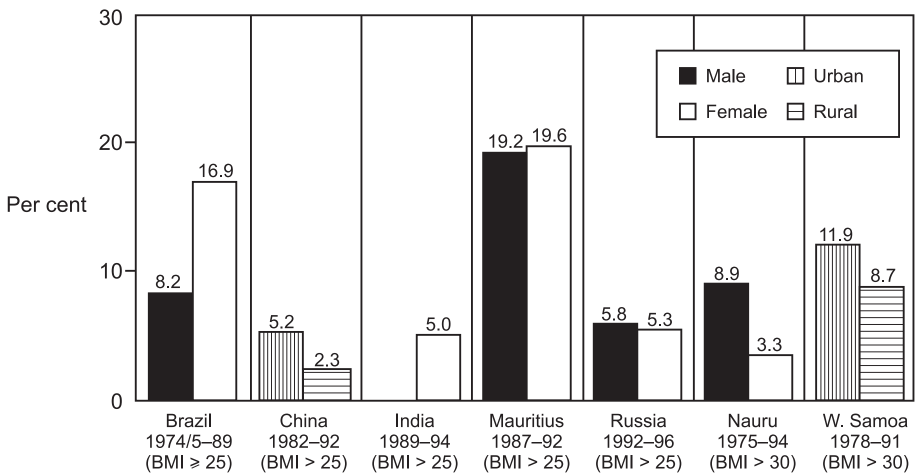


Figure 12.7 *Obesity trends: the percentage point increase in obesity prevalence per ten-year period*

by 230 per cent over a 21-year period. Interestingly, it was shown that the ratio between the underweight and overweight prevalence, a measure of the relative importance of each problem in the population, was dramatically affected between 1974 and 1989. In the case of all adults, the ratio was even reversed: in 1974, underweight exceeded overweight by 1.5 times while in 1989 those overweight exceeded the underweight by more than twice. These increases in the frequency of overweight occur for all incomes and both sexes, but they tend to be far more important among the poorest families.[36]

China

The shifts in diet, physical activity and overweight status in China are among the most rapid ever documented. The level of overweight status in China among adults is still low but the marked shifts in diet and activity and grade I overweight lead one to believe that major increases in grades I and II overweight will occur. These changes are much greater among urban residents of all income backgrounds and among middle- and higher-income rural residents.[19] In China we are able to explore the trends by income group for the 1989–1993 period and have found that the rate of increase among the urban and rural lowest income third is the greatest.

The rates of increase based on national nutrition surveys in China in 1982–1992 indicate a moderate rate of increase; however, this hides the more rapid shifts in diet, activity and obesity seen in the last few years.[44] The increase in the prevalence of 5.2 percentage points of grade I overweight during this ten-year period in urban areas is considerable. During the more recent period, the CHNS data for 1989–1993 show that there has been a consistent increase in obesity in urban and rural areas among adults. The CHNS 1989 survey results for this age group fit exactly in the middle of these results. Grade I and above obesity increased from 9.7 per cent in 1982 to 14.9 per cent between 1982 and 1993.

India

Unlike China, far fewer data are available for India. Information is available only for women of child-bearing age which indicates a small increase over the 19 years but a more rapid increase of 4.2 percentage points during the 1989–1994 period.

Russia

Russia has one of the highest rates of mortality related to CHD in the world. Despite shifts towards a lower-fat diet in the post-reform period, there is evidence of an increase in adult obesity. Data have been collected for seven rounds of the nationally representative Russian Longitudinal Monitoring Survey and there is over time a consistent increase in adult and also elderly obesity.[43] Figure 12.8 presents information on trends in body composition in Russia. The remarkable

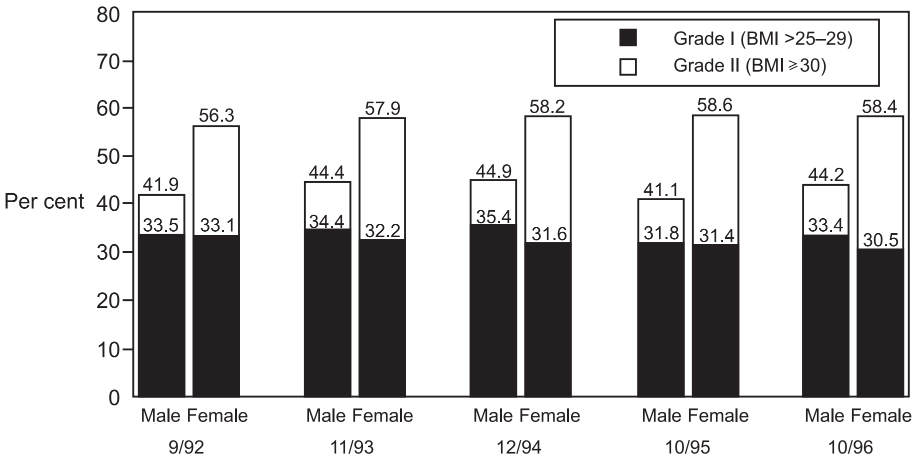


Figure 12.8 *Obesity trends in Russia, 1992–1996*

point to note is that the effects of the economic hardship in Russia have not been seen in the obesity trends. In 1996 the grade II obesity of females showed a decline. A much higher rate of increase in prevalence of obesity was found among grade II and above obesity for Russian females. Overall, the increase in total obesity is over five percentage points per ten-year period for Russia but future directions of this trend are less clear because the economy is in such flux.

The Health Implications: NIDDM and Related Conditions

A range of changes in health are accompanying the nutrition transition. As noted above, foremost is the reduction of infant mortality – and related to that is undernutrition. Wasting is being rapidly reduced in many countries and rates of stunting are also being lowered though recent information indicates that the rate of change has slowed considerably in the last few years.[45] At the same time, many adverse changes are taking place. The positive effects are not addressed here – effects that must not be lost nor minimized. Rather the focus is on the other side of the coin – the negative health effects which represent the most lasting and costly side effect of the nutrition transition.

There is a growing literature that documents rapid increases in NIDDM in many lower-income countries.[33,46,47] Other work indicates that many of the cardiovascular conditions related to NIDDM such as hypertension, dyslipidaemia and atherosclerosis are documented as increasing rapidly. The epidemiological prevalence data are spotty but indicate serious and high levels of these conditions, in particular NIDDM. NIDDM comprises 85 per cent or more of all diabetes cases. Recently, a most provocative cancer study has laid a strong basis for linking the diet, activity and body composition trends discussed above to the likelihood of increased rates of prevalence for a larger number of cancers.[48]

A related clinical and epidemiological literature highlights the importance of the same factors noted as being central to the nutrition transition – diet shifts, reduced physical activity and obesity – as also being critical determinants of NIDDM.[49–52] More recently this same literature has clarified the potential role for genetics and regional adiposity as they interact with these other factors.

Diet is the least understood determinant of NIDDM. A clear literature has shown that in terms of mechanisms and epidemiology, obesity and activity are closely linked to NIDDM. Several reviews lay out the case for these factors. Zimmet and his colleagues have been particularly earnest in exploring these issues at the population level in a number of lower-income and transitional societies.[51,52]

Some basic characteristics of NIDDM may provide a clear basis for linking key components of the nutrition transition – increases in obesity and reductions in activity – to the rapid increases in NIDDM in lower-income countries.

Obesity

It is clear that obesity, and more particularly upper-body regional distribution of the body fat, is a key parameter in the aetiology of NIDDM. A vast literature has shown significant direct obesity relationships with NIDDM and the animal literature backs up this relationship. The work on abdominal obesity and its effects is more recent, but appears to be promising in more precisely explaining the role that body composition plays. To the extent this abdominal obesity relationship holds, the metabolic programming hypothesis becomes that much more important in showing a link between foetal and infant nutritional insults and their relationship to adiposity in the upper body area. Law et al (see Barker[17]), in a follow-up study of British men, found abdominal fatness in adults to be associated with reduced foetal growth, manifested by low birthweight (LBW), and in particular LBW relative to placental weight. In a study of American white people and Hispanics, Valdez et al[53] found that the odds of expressing a syndrome consisting of dyslipidaemia, hypertension, unfavourable fat distribution and NIDDM were 1.72 times higher for the lowest compared to the middle third of birthweight.

In addition, there is a strong relative risk linking weight increases with diabetes. The odds of getting diabetes are considerable with a weight gain of 5–8kg for adults and they increase as weight gain goes up.[54]

Physical activity

It is understood that exercise affects insulin sensitivity such that heavy activity reduces the likelihood for a given level of obesity that a person will display the signs that allow him/her to be categorized as having NIDDM. In other words, physical activity lowers the serum insulin level or appears to do so. Zimmet reviews these relationships and notes other critical studies on this topic.[51,52]

Interactions of obesity and activity

Activity and obesity appear to interact but also to have separate effects. For example studies show that for each level of BMI or waist–hip ratio, there is an activity effect in terms of serum insulin level.

Genetic component

Zimmet and others who have focused on this issue as it relates to lower-income countries have felt that the highest genetic susceptibility was for Pacific Islanders, American-Indians, Mexican-Americans and other Hispanics, and Asian-Indians. Those with modest genetic susceptibility include Africans, Japanese and Chinese.[51,52] The age of onset of NIDDM is much lower for these populations and for a given level of obesity and waist–hip ratio it appears that the prevalence is higher. For instance, while the diagnosis is usually made after the age of 50 years, in these populations it is made much earlier.

Some of the articles that document the obesity increase, in particular those for Mauritius and the Pacific Islands and also for urban black South Africa also have shown a comparable rapid increase in the incidence of NIDDM and the biological precursors, higher glucose intolerance.[33,46,47]

O'Dea and colleagues[55] and also Galanis and colleagues[56] have explored the same issues in depth among Australian Aborigines and other South Pacific groups and have provided careful documentation of this linkage of the transition with NIDDM.

Evidence from dozens of smaller studies in China, the Western Pacific, South Africa, urban areas in many other countries, and other countries point clearly to an incipient major increase in cardiovascular disease in all of these countries.[47,57–59]

Discussion and Implications

The nutrition transition addresses a broad range of socioeconomic and demographic shifts that bring rapid changes in diet and physical activity levels to most regions of the world. The changes are occurring most rapidly as is shown by the shifts in the distribution of the population, income and occupation patterns. The diet changes, most specifically the shifts towards the higher fat and meat/reduced carbohydrate and fibre diet, is also a shift towards a more diverse and pleasurable diet. The activity patterns also represent a shift away from onerous, difficult labour-intensive activities. Thus, these dietary and physical activity shifts are desirable in many ways. Yet they carry with them many onerous nutritional and health effects. It is this paradox and complexity which makes it most difficult to understand ways to arrest the negative aspects of the nutrition transition. It is also clear that we must view the causes of obesity as environmental rather than personal or genetic.

We must be aware of the weak database on which this work relies. Documentation at the individual and household level of this transition exists in only a few countries. These countries, such as China, indicate a marked shift away from traditional coarse grains and towards refined grains and then towards meat, eggs and fats. They also indicate a strong propensity for increased income to be linked with increased dietary diversity and increased consumption of these higher fat 'Western diets'. Similarly they show marked changes in activity and obesity. Soon they will show the even more marked increases in CHD and NIDDM as others have shown in these countries. Yet, evidence for the shifts in physical activity is mainly indirect. The few studies that have monitored these trends have linked them to increased obesity but far more is needed in the way of research on this topic. This lack of research is a major gap, as are studies that collect both diet and activity data.

There is evidence that trends in obesity are not limited to one region, country or racial/ethnic group. The overall levels that are found in selected countries such as Mexico, South Africa, Malaysia, and nations of the Western Pacific are indicative of major public health problems. That these changes appear to be occurring across so many countries lends weight to the need to understand the underlying environmental causes related both to shifts in diet and activity rather than focusing attention solely on genetic causes of obesity. It also opens up the possibility that international studies can help to clarify the causes for these patterns.

It is likely that the rate of increase in obesity and NIDDM will increase rapidly, if the Barker metabolic programming hypothesis is correct. Stunting levels are very high in most lower-income countries. It is not unusual for 15–35 per cent of children to be stunted.[40] High rates of intrauterine growth retardation and LBW also exist. To the extent that fetal and infant insults, later combined with reduced activity and increased diet, lead to obesity and NIDDM, the African, Asian and Latin American regions might see rapid increases in the health complications associated with the nutrition transition.

The challenge is to devise ways to improve the lives of our citizens – that is to give people the more varied and tasty diets they want and less burdensome work – but also to prevent obesity, NIDDM, CHD and the other major diseases of civilizations. But we have few examples of countries that have been able to tackle these issues at the national level. Elsewhere I have summarized some of these issues. Milio has studied these trends most systematically.[60–62] The Scandinavian countries are unique in attempting to redirect their diets and health with prevention at the national level and they have done this with mixed success. Lower-income countries are only beginning to discuss and consider options for dealing with obesity. So long as poverty and hunger affect portions of the population, at the international and national level, the public and politicians are more likely to address that problem than they are to consider obesity. This means that not only are we trying to redirect popular changes in diet and activity, but we are also attempting to fight them during a time when public attention is focused on these problems of poverty and dietary deficit. Our solutions must not adversely affect the undernourished. At the same time we must begin to develop an array of large-scale options that national governments can implement. As with any other epidemic, we must focus much of our energy on environmental solutions.

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13

Diet and Health: Diseases and Food

Tim Lang and Michael Heasman

Let Reason rule in man, and he dares not trespass against his fellow-creature, but will do as he would be done unto. For Reason tells him, is thy neighbour hungry and naked today, do thou feed him and clothe him, it may be thy case tomorrow, and then he will be ready to help thee.

Gerrard Winstanley, English Leveller, 1609–1676[1]

Core Arguments

The Productionist paradigm is critically flawed in respect of human health. Half a century ago it responded to issues then seen as critical but which now require radical revision. While successfully raising the caloric value of the world food supply, it has failed to address the issue of quality, and as a result, there is now a worldwide legacy of externalized ill health costs. The world's human health profile is now very mixed. Within the same populations, in both developed and developing countries, there exists diet-related disease due both to under- and over-consumption. The pattern of diet that 30 years ago was associated with the affluent West is increasingly appearing in the developing countries, in a phenomenon known as the 'nutrition transition': while the incidence of certain diet-related diseases has decreased, such as heart disease in the West, others are increasing, particularly diabetes and obesity worldwide, and heart disease in the developing world. Massive global inequities in income and expectations contribute to this double burden of disease, and current policies are failing to address it.

Introduction

One of the key Food Wars is over the impact of the modern diet on human health. In the last quarter of the 20th century, nutrition moved from the sidelines of public

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health to being central to the marketing of foodstuffs, and major public health campaigns urged consumers to improve their diets.

This human health dimension is central to our critique of the Productionist paradigm in two respects. First, even though global food production has increased to meet caloric needs, its nutritional content may be less than desirable. Second, food distribution remains deficient: nearly a billion people remain malnourished. In this chapter, we explore the relationship between diet and the range of disease and illnesses that are associated with food choices. We discuss, too, the existence of gross inequalities within and between countries in the form of food poverty amidst food abundance and wealth.

In late 2002 and 2003, a wave of new public health reports reminded the world that diet is a major factor in the causes of death and morbidity. Although deeply unpalatable to some sections of the food industry, these reports were sober reminders of the enormity and scale of the public health crisis. The joint WHO and FAO's 2003 report on diet, nutrition and the prevention of chronic diseases drew attention to high prevalence of diseases which could be prevented by better nutrition, including:[2]

- obesity;
- diabetes;
- cardiovascular diseases;
- cancers;
- osteoporosis and bone fractures;
- dental disease.

Of course, these diseases are not solely exacerbated by poor diet but also by lack of physical activity. In truth, this report was only reiterating the story of nutrition's impact on public health that had been rehearsed for many years, and the evidence for which was judged to be remarkably sound, but as Dr Gro-Harlem Brundtland, then the Director-General of the WHO, stated in the report: 'What is new is that we are laying down the foundation for a global policy response.' To this end, the WHO set up an international consultation dialogue to prepare its global strategy on diet, physical activity and health, scheduled to be launched in 2004. By international agency standards, this relatively speedy shift from evidence to policy making indicates the real urgency of the problem. The draft strategy was launched ahead of schedule in December 2003.[3]

Already by 2002, the WHO had produced a major review of the national burdens that such diseases cause. Of the top ten risk factors associated with non-communicable diseases, food and drink contribute to eight (with the two remaining – tobacco and unsafe sex – not associated with diet and food intake):[4]

- blood pressure;
- cholesterol;
- underweight;

- fruit and vegetable intake;
- high body mass index;
- physical inactivity;
- alcohol;
- unsafe water, sanitation and hygiene.

In the 2003 World Cancer Report, the most comprehensive global examination of the disease to date, the WHO stated that cancer rates could further increase by 50 per cent to 15 million new cases in 2020.[5] To stem the rise of this toll, the WHO and the International Agency for Research on Cancer (the IARC) argued that three issues in particular need to be tackled:

- Tobacco consumption (still the most important immediate avoidable risk to health).
- Healthy life-style and diet, in particular the frequent consumption of fruit and vegetables and the taking of physical activity; early detection and screening of diseases to allow prevention and cure.

In addition to these UN reports, the International Association for the Study of Obesity (the IASO) revised its figures of the global obesity pandemic: it estimates that 1.7 billion people are overweight or obese, a 50 per cent increase on previous estimates. The IASO's International Obesity Task Force stated that the revised figures meant that most governments were simply ignoring one of the biggest risks to world population health.[6]

These reports testify to an extensive body of research and evidence from diverse sources around the world of the link between food availability, consumption styles and specific patterns of disease and illness. Table 13.1 confirms some of the diet-related causes of death throughout the world. Good health and longevity were intended to result from ensured sufficiency of supply; at the beginning of the 21st century, far from diet-related ill health being banished from the policy agenda, it appears to be experiencing a renewed crisis.

Under the old Productionist paradigm, the main focus was under-nutrition. Yet at the end of the 20th century, with diseases such as heart disease, cancers, diabetes and obesity rampant worldwide, not just in the affluent West, a new focus must be placed on diet and inappropriate eating. In this chapter, we begin to explore wider societal changes which impose progress in this regard through demographic shifts, maldistribution of and poor access to food, and spiralling health-care costs. These factors add weight to our argument that the Productionist paradigm is beyond its own sell-by date.

Policy making is failing to address the causes of these food-related health problems and too often resorts to only palliative measures. This is partly because the Productionist paradigm's approach to health narrows the framework for considering alternative solutions: by being centred on striving to increase output, it has taken only a medicalized, rather than a socially determined, view of health.

Table 13.1 *Some major diet-related diseases*

Problem	*Extent/comment*
Low birthweights	30 million infants born in developing countries each year with low birthweight: by 2000, 11.9 per cent of all newborns in developing countries (11.7 million infants)
Child under-nutrition	150 million underweight preschool children: in 2000, 32.5 per cent of children under 5 years in developing countries stunted, amounting to 182 million preschool children. Problem linked to mental impairment. Vitamin A deficiency affects 140–250 million schoolchildren; in 1995, 11.6 million deaths among children under 5 years old in developing countries
Anaemia	Prevalent in schoolchildren; maternal anaemia pandemic in some countries
Adult chronic diseases	These include adult-onset diabetes, heart disease and hypertension, all accentuated by early childhood under-nutrition
Obesity	A risk factor for some chronic diseases (see above), especially adult-onset diabetes.[7] Overweight rising rapidly in all regions of the world
Underweight	In 2000, an estimated 26.7 per cent of preschool children in developing countries.
Infectious diseases	Still the world's major killers but incidence worsened by poor nutrition; particularly affects developing countries
Vitamin A deficiency	Severe vitamin A deficiency on the decline in all regions, but sub-clinical vitamin A deficiency still affects between 140 and 250 million preschool children in developing countries, and is associated with high rates of morbidity and mortality

Source: Adapted from ACC/SCN 2000[8]

Could the proponents of Productionism have anticipated the scale of these most recent health concerns? To some extent, they could not. Even excessive intake of fats as causing ill health might have been something of a shock for the Productionist paradigm, as it was almost heretical to argue that too much of a nutrient could be harmful to health.[9] Part of the problem here was the essential paternalism of the paradigm which assumed total knowledge of all variables needed to make good food policy: governments and companies could be trusted to look after the public health; the consumers' role was to select products to create their own balanced diets. Recent history, however, has shown that governments and the food supply chain failed to adapt to new scientific knowledge in relation to food and health. Nationally and internationally, the influence of health scientists on public policy has been minimal. Consumerism triumphed. To some extent, too, the public health world has colluded in its own marginalization from 'live' policy making by its fixation with deficiency diseases: for example, on programmes of food fortification or on protein shortages which could be made up by increased meat and dairy production. Despite a successful worldwide campaign to increase intake of folic acid following the discovery of its connection with spina bifida (neural tube defect syndrome), the overall impact of nutritional science in policy making has been negligible. Its response to the current epidemic of heart disease has been 'health education' – advice, leaflets and exhortations to change behaviour – explaining it as caused by modern life-styles, rather than by preventable dietary deficiencies. Almost as soon as the Productionist paradigm was put in place worldwide in the last half of the 20th century, global campaigns were needed to address the increase in degenerative diseases. However, the necessary policy instruments were not in place to tackle the health impact of long-term shifts in diet. The UN bodies which noted the evidence of new patterns of ill health were merely intergovernmental bodies who lacked any administrative power and influence to act on the global and national level. Commercial interests, on the other hand, had no such limits and could pursue their global ambitions, selling foods and a life-style around the world without regard to their consequences, and being able to defend their actions as being in the public interest.

Instead, the developed world now must confront one of the most challenging food and health disasters ever to face humankind: an epidemic of obesity with little prospect of an end in sight and the prospect of a new wave of diet-related diseases in its wake. It has little in its armoury with which to combat the causes of obesity, now affecting significant numbers of children and with even graver implications for future population health. Health education is ineffective; consumerism is part of the problem, but politically it is nearly sacrosanct.

Meanwhile, hunger and insufficiency continue, ironically, to prevail. As a 1995 FAO review of the global picture starkly put it: '[H]unger … persists in developing countries at a time when global food production has evolved to a stage when sufficient food is produced to meet the needs of every person on the planet.'[10] Over-consumption and under-consumption coexist. There is gross inequality of global distribution and availability of food energy. The same review asserted that Western Europe, for example, has in theory 3500 kilocalories (kcal) available per person per day and North America has 3600, while sub-Saharan Africa has 2100 and India has 2200. By 2015 the FAO calculates that 6 per cent of the world's population (462 million people) will be living in countries with under 2200kcal available per person. And by 2030, in the most optimistic scenario, in sub-Saharan Africa 15 per cent of the population will be undernourished. Numbers of the undernourished look set only to decline much more slowly than suggested by targets, for example those of the World Food Summit of 1996.[11]

The transnational nature of these patterns of diet-related disease demands public policy attention. The enormity of this human health problem cannot be overemphasized. Diseases associated with deficient diet account for 60 per cent of years of life lost in the established market economies.[12]

Scientists categorize diseases into two broad groups: communicable (carried from person to person or via some intermediary factor; these include diseases such as malaria, food poisoning, SARS); non-communicable (acquired by life-style or other mismatch between humans and their environment, such as cardiovascular disease and cancers). Table 13.2 indicates that in the developed world, deaths

Table 13.2 *Number of deaths by WHO regions, estimates for 2002 (thousands)*

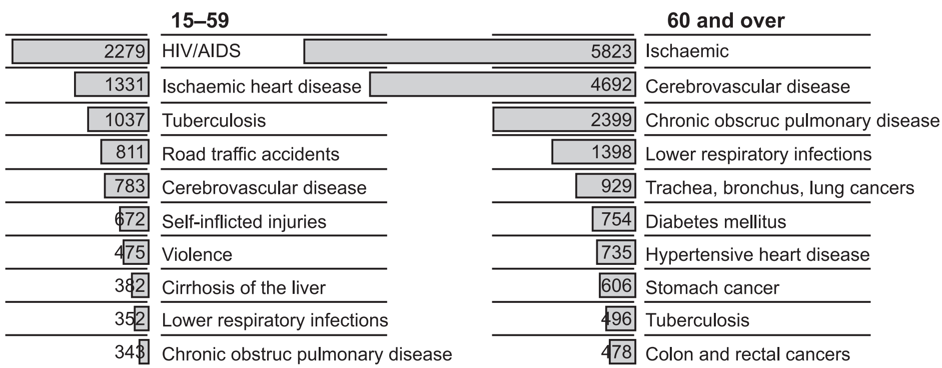
	Africa	*Western Pacific*	*Europe*	*The Americas*	*Eastern Mediterranean*	*South-East Asia*	*Total world-wide*
Infectious & parasitic diseases	5787	794	212	394	959	2968	11,114
Cardiovascular diseases	1136	3817	4857	1927	1080	3911	16,728
Cancers	410	2315	1822	1115	272	1160	7094
Respiratory infections[a]	1071	511	273	228	365	1393	3841
Perinatal and maternal causes	585	371	69	192	371	1183	2771
Injuries	747	1231	803	540	391	1267	4979

Note: a This does NOT include respiratory diseases; includes upper and lower respiratory infections and otitis media.

Source: WHO, *Shaping the Future*, World Health Report, Geneva, 2003, calculated from Annex Table 2

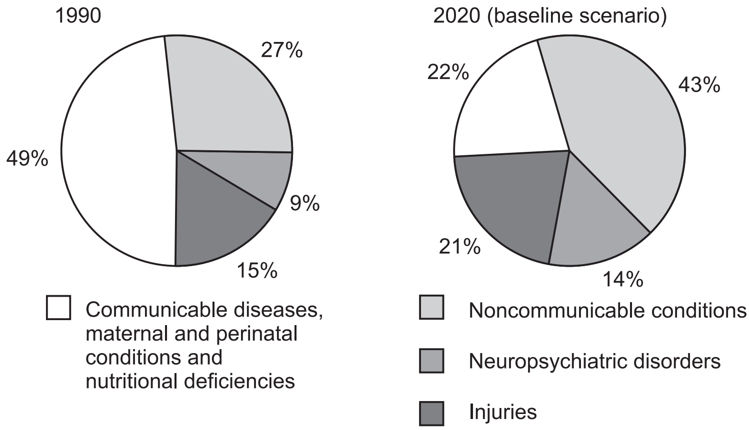
through infectious and parasitic diseases are very low compared to developing countries, while diet-related non-communicable diseases like coronary heart disease and cancers are high in both developed and developing worlds. Degenerative disease rates are already high in the developing world. Figure 13.1 gives the leading causes of mortality by age to give another view of the global disease patterns.

The WHO and the FAO reports stress that world health in general is in transition with non-communicable diseases now taking a higher toll than communicable



Source: WHO, *World Health Report 2003*

Figure 13.1 *Leading causes of mortality, by age, 2002*



Source: WHO, *Evidence, Information and Policy*, 2000

Figure 13.2 *Anticipated shift in global burden of disease 1990–2020, by disease group in developing countries (WHO)*

diseases. Figure 13.2 shows the WHO prognosis of how the rates of non-communicable disease are expected to rise. Factors in this health transition include diet, demographic change (such as an ageing population) and cultural factors related to globalization.

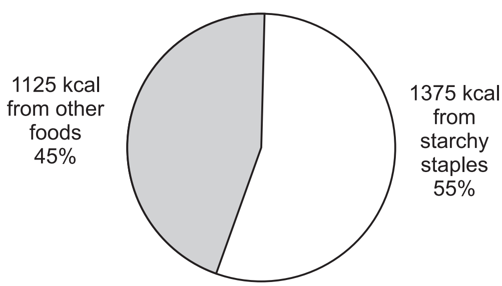
The Nutrition Transition

In a series of papers, Professor Barry Popkin and his colleagues have argued that there is what they term a 'nutrition transition' occurring in the developing world, associated primarily with rising wealth.[13,14] The thesis, which has been extensively supported by country and regional studies,[15] argues simply that diet-related ill health previously associated with the affluent West is now becoming increasingly manifest in developing countries.[16,17] The 'nutrition transition' suggests shifts in diet from one pattern to another: for example, from a restricted diet to one that is high in saturated fat, sugar and refined foods, and low in fibre. This transition is associated with two other historic processes of change: the demographic and epidemiological transitions. Demographically, world populations have shifted from patterns of high fertility and high mortality to patterns of low fertility and low mortality. In the epidemiological transition, there is a shift from a pattern of disease characterized by infections, malnutrition and episodic famine to a pattern of disease with a high rate of the chronic and degenerative diseases. This change of disease pattern is associated with a shift from rural to urban and industrial life-style.

WHO researchers have noted that changes in dietary patterns can be driven not just by rising income and affluence but also by the immiseration that accompanies others' rising wealth;[18] low income countries are experiencing the effects of the transition but cannot afford to deal with them.[19] Popkin argues that, while the nutrition transition brings greater variety of foods to people who previously had narrow diets, the resulting health problems from the shift in diet should not be traded off against the culinary and experiential gains. Consumers might enjoy the new variety of foods that greater wealth offers but they are often unaware of the risk of disease that can follow. The implications of the nutrition transition now ought to exercise the minds of global as well national policy makers: certainly health policy specialists are concerned at the rise of degenerative diseases in low- and middle-income countries.[20,21]

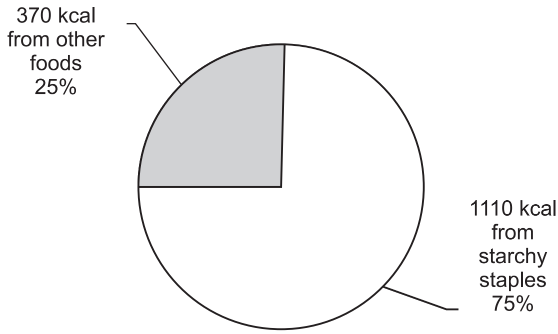
Nutrition may have recently become a key notion in modern dietary thinking but it only echoes the insights of an earlier generation of researchers which included nutrition and public health pioneers such as Professors Trowell and Burkitt, whose observations from the 1950s to the 1980s led them to question 'whether Western influence in Africa, Asia, Central and South America and the Far East is unnecessarily imposing our diseases on other populations who are presently relatively free of them'.[22] Trowell and Burkitt, both with long medical experience in Africa, could easily explain the variation in infectious diseases, but not the variation in rates of non-infectious diseases such as heart disease between countries at different economic levels of wealth and development. In Africa in the post-World War II period, they witnessed the rise of key indicators for diseases such as heart disease and high blood pressure in peoples who had previously had little experience of them.[23] The dietary transition is swift. An FAC study of very undernourished Chinese people (living on 1480kcal per day) shows that they derive three-quarters of their energy intake from starchy staples such as rice, while better-fed Chinese (living on 2500kcal per day) are able to reduce their energy intake from such staples and to diversify their food sources (see Figures 13.3 and 13.4 which compare the diets of undernourished and well-nourished people in China).

Popkin has shown how this same process occurs in both urban and rural populations in developing countries with rising incomes. Figures 13.5 and 13.6 show



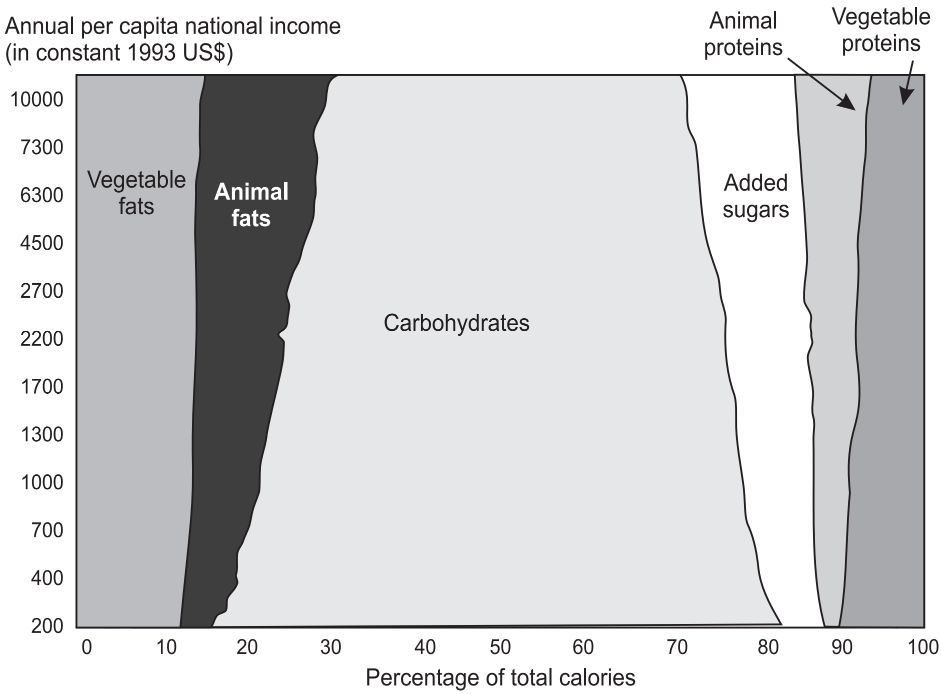
Source: National Survey of Income and Expenditure of Urban Households. Government of China, 1990; FAO, *State of Food Insecurity*, 2000; www.fao.org

Figure 13.3 *Diet of a well-nourished Chinese adult (2500kcal/person/day)*



Source: National Survey of Income and Expenditure of Urban Households, Government of China, 1990; www.fao.org

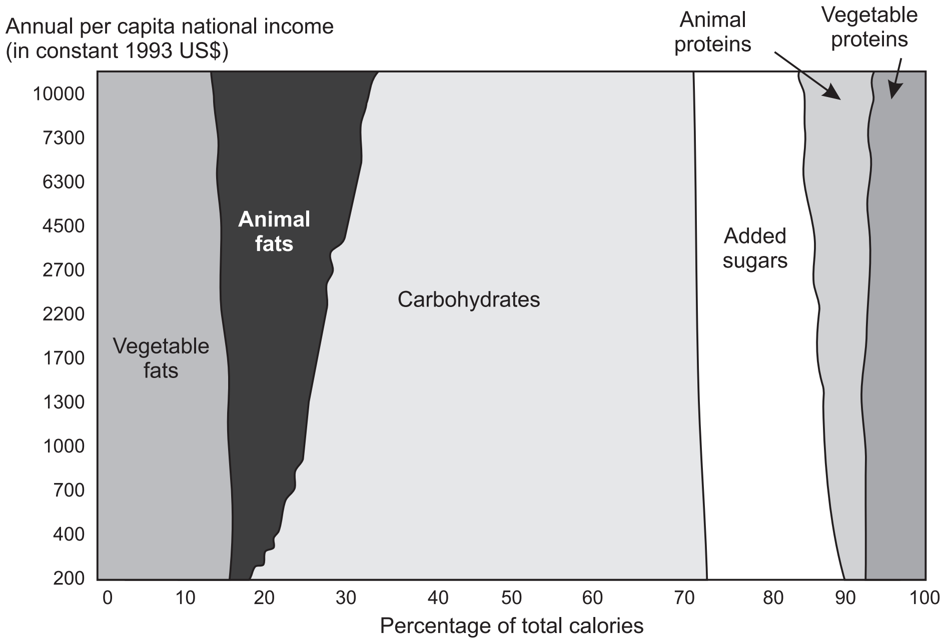
Figure 13.4 *Diet of an undernourished Chinese adult (1480kcal/person/day)*



Source: FAO/World Bank/Popkin, B (1998) 'The nutrition transition and its health implications on lower income countries', *Public Health Nutrition*, 1, 5–21

Figure 13.5 *Relationship between the proportion of energy from each food source and GNP per capita, with the proportion of the urban population at 25 per cent, 1990*

the relationship between per capita income and what predominantly rural and predominantly urban populations eat as both get wealthier:[24] both eat more meats and fats, and reduce carbohydrate, as a proportion of their overall diet. But there



Source: FAO/World Bank/Popkin, B (1998) 'The nutrition transition and its health implications on lower income countries', *Public Health Nutrition*, 1, 5–21

Figure 13.6 *Relationship between the proportion of energy from each food source and GNP per capita, with the proportion of the urban population at 75 per cent, 1990*

still remain differences between urban and rural populations, probably due to their different levels of activity, access to dietary ingredients and cultural mores.[25] The more urban population also consumes more added sugars as it gets wealthier, whereas the rural population consumes less. Popkin and his colleagues' point is that changing economic circumstances markedly shape the mix of nutrients in the diet and that life-style factors – such as the degree of urbanization[26] and changing labour patterns – have a major effect on health.

The transition is occurring in areas that usually receive little food policy attention. A study by the WHO has reported that in the Middle East changing diets and life-styles are now resulting in changing patterns of both mortality and morbidity there too.[27] Dietary and health changes can be rapid. In Saudi Arabia, for instance, meat consumption doubled and fat consumption tripled between the mid-1970s and the early 1990s; in Jordan, there has, in the same timescale, been a sharp rise in deaths from cardiovascular disease. These problems compound older Middle-Eastern health problems such as protein-energy malnutrition, especially among children. In China, the national health profile began to follow a more Western pattern of diet-related disease as the population gradually urbanized,[28] coinciding with an increase in degenerative diseases. Consumption of legumes such as soyabean was replaced by animal protein in the form of meat. One expert nutritional review of this problem concluded that exhorting the Chinese people to consume more soy when they were voting with their purses to eat more meat would be ineffective 'in the context of an increasingly free and global market'.[29] Such studies can suggest that the battle to prevent Western diseases in the developing world appears already to have been lost. If the nutrition transition is weakening health in China, the world's most populous and fastest economically growing nation, which has 22 per cent of the world's population but only 7 per cent of its land, what chance is there for diet-related health improvements throughout the developing world?

As populations become richer, they substitute cereal foods for higher-value protein foods such as milk, dairy products and meat, increased consumption of which is associated with Westernization of ill health. Relatively better-off populations also consume a greater number of non-staple foods and have a more varied, if not healthier, diet.[30] Thus we have the modern nutritional paradox: in the same low-income country there may be ill health caused by both malnutrition and over-nutrition; in the same rural area of a poor country both obesity and underweight can coexist.

In policy terms the challenge is whether India, China, Latin America or Africa, for example, can afford the technical fixes that the West can resort to in order to improve diet-related health:[31] coronary bypass operations; continuous drug regimes; expensive drugs and foods with presumed health-enhancing benefits;[32] and subscriptions to gyms and leisure centres. The affluent middle classes in the developed world might be able to afford such fixes but the vast numbers in the developing world certainly will not. Technical fixes are not societal solutions.

It could be argued that the increase in degenerative diseases is the inevitable down-side of economic progress. The problem for policy making is how to differentiate between protecting the already protective elements of traditional, indigenous diets such as legumes, fruit and vegetables, and opening up more varied food markets, which is deemed to be good economic policy. In practice, too few policy makers in the developing world have been prepared to fight to keep 'good' elements of national and local diets or to constrain the flow of Western-style foods and drinks into their countries lest they infringe support for trade liberalization. Thus, in stark terms, trade and economic policies have triumphed over health interests. US-style fast foods – the 'burgerization' of food cultures – have been hailed as modernity. We must now expose the production, marketing and prices of fast food,[34,35] their nutritional value and their impact on health.[36]

Three Categories of Malnutrition: Underfed, Overfed, and Badly Fed

More than 2 billion people in the world today have their lives blighted by nutritional inadequacy. On one hand, half of this number do not have enough to eat;

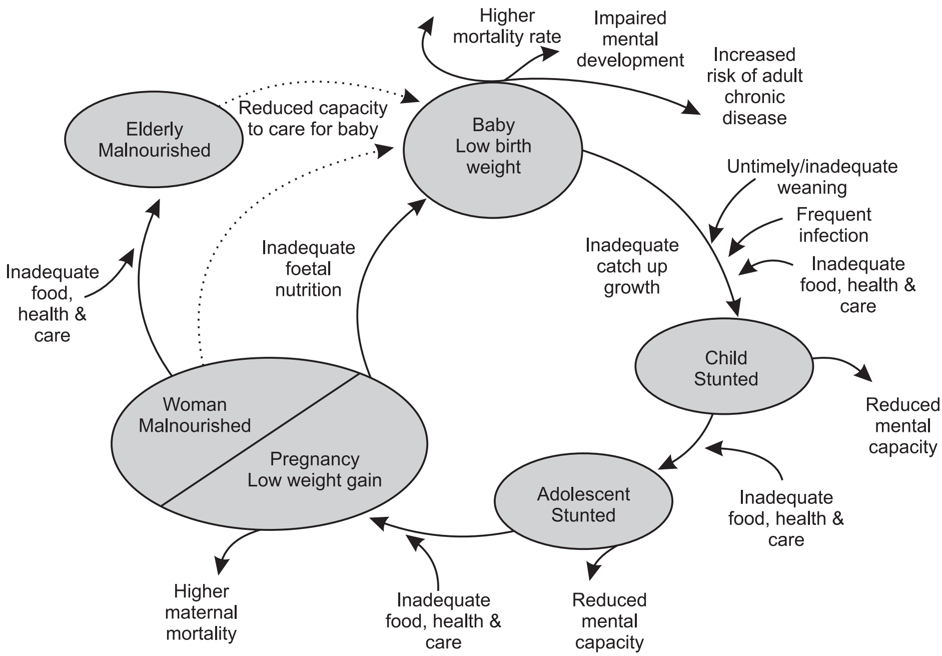
Table 13.3 *Types and effects of malnutrition*

Type of malnutrition	*Nutritional effect*	*No. of people affected globally (× billion)*
Hunger	deficiency of calories and protein	at least 1.2
Micronutrient deficiency	deficiency of vitamins and minerals	2.0–3.5
Over-consumption	excess of calories, often accompanied by deficiency of vitamins and minerals	at least 1.2–1.7

Source: Gardner and Halweil (2000), based on WHO, IFPRI, ACC/SCN data[33]

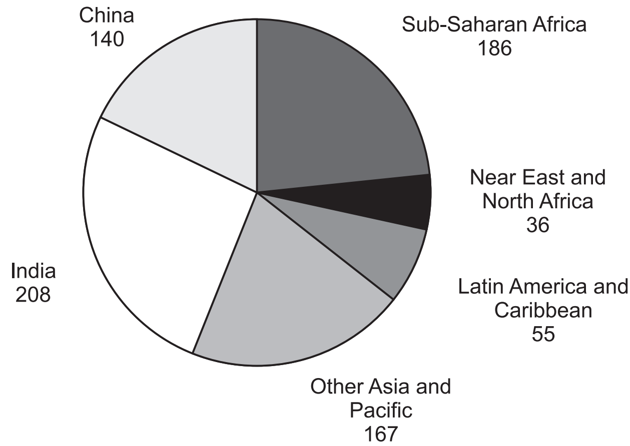
on the other hand, a growing army of people exhibit the symptoms of overfeeding and obesity. In both cases, the international communities are floundering for solutions, and malnutrition results, as indicated by Table 13.3.

Figure 13.7 highlights the role of the mother in infant health. Even before conception, the mother's own nutrition is vital.[37] It is now understood that children who are born with a low birthweight are at increased risk of developing heart disease and that good nourishment of the foetus is key. That nutrition affects disease patterns and life expectancy is now well documented.[38]



Source: ACC/SCN (2000) *Nutrition through the Life Cycle: 4th Report on the World Nutrition Situation*. UN Administrative Committee on Co-ordination Subcommittee on Nutrition, New York, p8

Figure 13.7 *Life cycle – the proposed causal links*



Source: State of Food Insecurity in the World 2000, available at www.fao org/DOCREP/X8200E/x8200e03.htm#P0_0

Figure 13.8 *Number of undernourished by region, 1996–1998 (millions)*

One of the particularly tragic consequences of undernourishment is its impact on the worlds children. UNICEF calculates that 800 million children worldwide suffer malnutrition at any given time (Figure 13.8 gives the FAO's estimated locations of these millions. Table 13.4 then gives the sobering projections for 2015 and 2030.) High proportions of Asian and African mothers are undernourished, largely due to seasonal food shortages, especially in Africa. About 243 million adults in developing countries are deemed to be severely undernourished.[39] This type of adult under-nutrition can impair work capacity and lower resistance to infection.

Against a rapid growth in world population, well-informed observers agree that greater food production is needed for the future.[40–43] One estimate suggests that by 2020 there will be 1 billion young people growing up with impaired mental

Table 13.4 *Projected trends in undernourishment by region, 1996–2030*

	1996–98	*2015*	*2030*	*1996–98*	*2015*	*2030*
	Per cent of population			*Millions of people*		
Sub-Saharan Africa	34	22	15	186	184	165
Near East/North Africa	10	8	6	36	38	35
Latin America and the Caribbean	11	7	5	55	45	32
China and India	16	7	3	348	195	98
Other Asia	19	10	5	166	114	70
Developing countries	18	10	6	791	576	400

Source: FAO (2000) *Agriculture: Towards* 2015/30, Technical Interim Report, April, Rome, FAO, www.fao.org development due to poor nutrition. At a conservative estimate, this means there will be 40 million young people added to the total each year.[44]

The Obesity Epidemic

As early as 1948, there were medical international groups researching the incidence of obesity in various countries.[45] There were official reports at country level by the early 1980s,[46] and there has also been a commercial and consumer response to obesity for even longer.[47] But the grip of international obesity was in fact confirmed by the WHO's Task Force on Obesity in 1998. Today, overweight and obesity are key risk factors for chronic and non-communicable diseases.[48] In developing countries obesity is more common amongst people of higher socioeconomic status and in those living in urban communities. In more affluent countries, it is associated with lower socioeconomic status, especially amongst women and rural communities.[49] Historically and biologically, weight gain and fat storage have been indicators of health and prosperity. Only the rich could afford to get fat. By 2000, the WHO was expressing alarm that more than 300 million people were defined as obese, with 750 million overweight, i.e. pre-obese: over a billion people deemed overweight or obese globally.[50] But by 2003, this figure had been radically revised upwards when the IASO calculated that up to 1.7 billion people were now overweight or obese. The new figures were in part due to more accurate statistics but also to the recalculation of obesity benchmarks, which acknowledged rising obesity in Asia.[51]

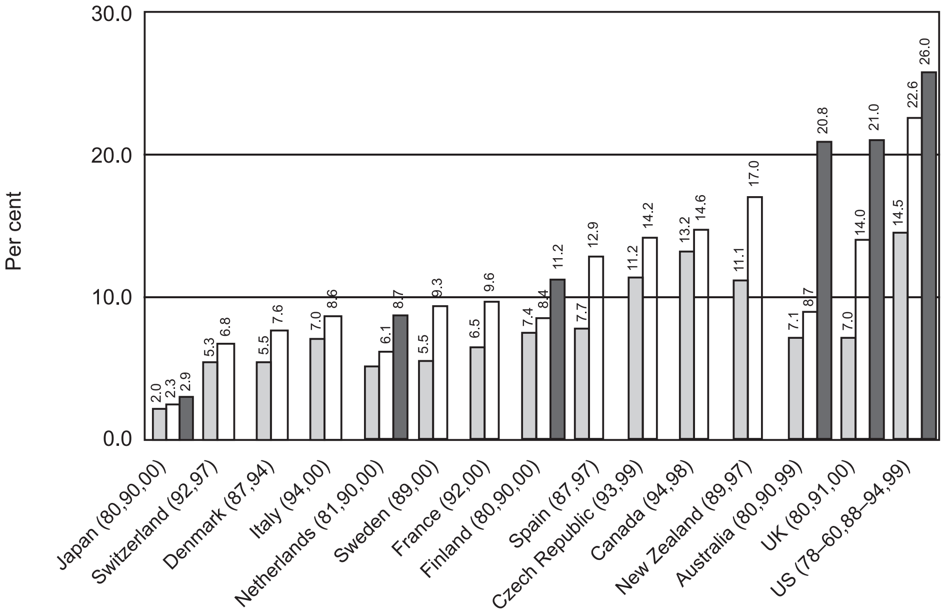
Particularly worrying is that extreme degrees of obesity are rising even faster than the overall epidemic: in 2003, 6.3 per cent of US women, that is 1 in 16, were morbidly obese, with a body mass index of 40 or more.

Obesity is defined as an excessively high amount of body fat or adipose tissue in relation to lean body mass. Standards can be determined in several ways, notably by calculating population averages or by a mathematical formula known as 'body mass index' (BMI),[52] a simple index of weight-for-height: a person's weight (in kilos) divided by the square of the height in metres (kg/m^2). BMI provides, in the words of the WHO, 'the most useful, albeit crude, population-level measure of obesity'. A personal BMI of between 25 and 29.9 is considered overweight; 'obesity' means a BMI of 30 and above; a personal BMI of less than 17 is considered underweight. There is some argument about whether the definition of overweight (a BMI within the 25–29.9 range) should be lowered from 25 to 23, in which case tens of millions more people would be considered overweight, and such an unofficial reclassification has led to the disparity between current world obesity figures.

BMI levels are a useful predictor of risk from degenerative diseases. Unutilized food energy is stored as fat. Currently, the US National Institutes of Health consider that all adults (aged 18 years or older) who have a BMI of 25 or more are at risk from premature death and disability as a consequence of overweight and obesity.[53] Men are at risk who have a waist measurement greater than 40 inches (102cm); women are at risk who have a waist measurement greater than 35 inches (88cm). Whilst height is obviously also taken into consideration, we should regard these measurements as key health benchmarks.

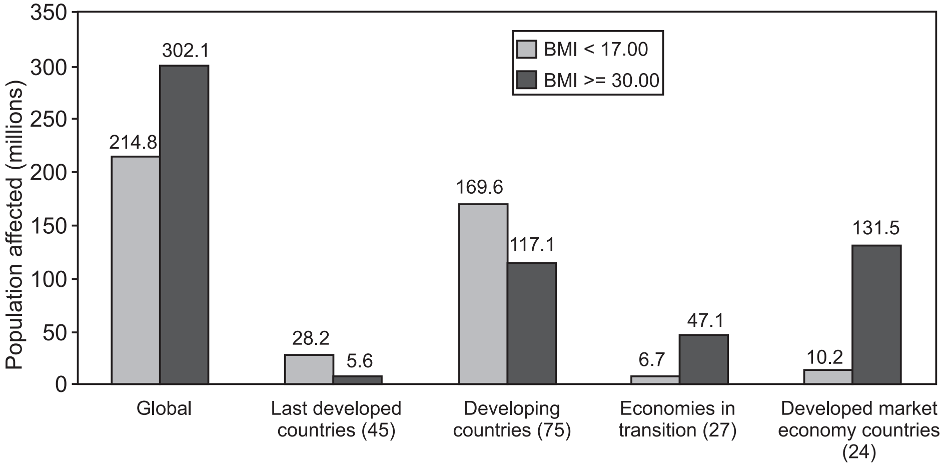
Figure 13.9 shows how, in a remarkably short time, the rate of obesity within countries is rising. In the UK, for instance, between 1980 and 2000, obesity trebled from 7 per cent of the population to 21 per cent.[54] Particularly alarming is that the 'North Americanization' of obesity is spreading down Latin America.[55] Figure 13.10 illustrates the level of obesity in comparison to underweight in developed and developing countries. In many countries, levels of obesity are double what they were 15 years ago.[56] In Peru, Tunisia, Colombia, Brazil, Costa Rica, Cuba, Chile, Mexico and Ghana, for example, overweight adults outnumber those who are thin. Even Ethiopia and India, traditionally beset by under-nutrition[57] and starvation now have the added burden of an emerging obesity problem. The trend to obesity is occurring in countries with different economic profiles, from the Asian 'Tiger' economies to the oil-rich Middle East.[58]

Rising obesity rates among children are particularly troubling to health professionals, as this trend suggests massive problems of degenerative disease for the future. In Jamaica and Chile, for instance, one in ten children is obese; in Japan, a country historically with a very low incidence of fat in its diet and with a low incidence of



Source: OECD Health Data 2002, available at www.oecd.org/pdf/M00031000/M00031130.pdf

Figure 13.9 *Obesity in adult population across OECD countries*



Source: WHO, *Nutrition for Health and Development: A Global Agenda for Combating Malnutrition*. 2000, available at www.who.inVnut/dbj3mLhtrn

Figure 13.10 *Global population affected by underweight and obesity in adults, by level of development, 2000*

obesity, the frequency of obesity in schoolchildren has increased from 5 per cent to 9 per cent for girls and 10 per cent for boys in 1996.[59] (Table 13.5 summarizes the rapid rise in obesity as measured by comparing initial surveys with follow-up worldwide studies. The final column of the table shows how obesity is becoming out of control in developed and developing countries alike.) Even in Australia, obesity rose 3.4-fold for boys and 4.6-fold for girls between 1985 and 1995; in Egypt, 3.9-fold between 1978 and 1996; in Morocco, 2.5-fold in just five years, from 1987 to 1992; in Scotland by 2.3-fold for boys and 1.8-fold for girls between 1984 and 1994. A child's weight can be thrown off balance by a daily consumption of only one sugar-sweetened soft drink of 120kcals; over ten years, this intake would turn into 50kg of excess growth. Although their review also fully acknowledged the role of genetics, the authors pointed to pressures on children's diets from advertisements to help explain the rapidity of consumption and obesity changes.[60]

Health education seems to be powerless before this rising tide of obesity. On the island of Mauritius, for instance, a study which examined adults over a period of five years found that, despite a national programme promoting healthy eating and increased physical activity, obesity levels had increased dramatically:[61] men with a BMI above 25 increased from 26.1 per cent to 35.7 per cent and for women the figure grew from 37.9 per cent to 47.7 per cent during the five-year study. The government of Mauritius concluded that a National Nutrition Policy and National Plan of Action on Nutrition was needed.[62] Even in the US, the homeland of fast food, President George W. Bush was so alarmed by the obesity crisis that in 2002 he launched a national debate. He has long had good reason for concern,[63] as even as far back as 1986, the economic costs of illness associated with overweight in the US were estimated to be $39 billion; today the estimated cost of obesity and overweight is about $117 billion.[64] The rise in US obesity is dramatic: between 1991 and 2001, adult obesity increased by 74 per cent. The percentage of US children and adolescents who are defined as overweight has more than doubled since the early 1970s, and about 13 per cent of children and adolescents are now seriously overweight.[65] These general US figures disguise marked differences between ethnic groups and income levels: according to the Centers for Disease Control and Prevention, 27 per cent of black and about 21 per cent of Hispanics of all ages are considered obese – that is, a third overweight – compared with a still worrying but lower 17 per cent among whites.[66] The poor are more obese than the more affluent within the US. The price of food is a key driver of obesity: saturated fats from dairy and meat and hydrogenated (trans) fats are relatively cheap.[67]

The connection between overweight and health risk is alarmingly highlighted by the following list of the physical ailments that an overweight population (with a BMI higher than 25) is at risk of:[68]

- high blood pressure, hypertension;
- high blood cholesterol, dyslipidemia;
- type-II (non-insulin-dependent) diabetes;
- insulin resistance, glucose intolerance;
- hyperinsulinaemia;
- coronary heart disease;
- angina pectoris;
- congestive heart failure;
- stroke;
- gallstones;
- cholescystitis and cholelithiasis;
- gout;
- osteoarthritis;
- obstructive sleep apnea and respiratory problems;
- some types of cancer (such as endometrial, breast, prostate and colon);
- complications of pregnancy;
- poor female reproductive health (such as menstrual irregularities, infertility and irregular ovulation);
- bladder control problems (such as stress incontinence);
- uric acid nephrolithiasis;
- psychological disorders (such as depression, eating disorders, distorted body image and low self-esteem).

There is a vocal position – particularly articulated in the US – arguing that the critique of obesity is an infringement of personal liberty and 'size-ist', making cultural value statements. If someone wants to be fat and is content and loved by others, goes this argument, what does it matter? The list of health problems given

Table 13.5 *Global increases in the prevalence of childhood obesity*[a]

Country	*Index of measurement*	*Age of children*	*Date of first study (% obesity)*	*Date of second study (% obesity)*	*Growth of obesity incidence from first to second study*
USA[b]	BMI=95th percentile	6–11 12–19	1971/74 (4%) 1971/74 (6%)	1999 (13%) 1999 (14%)	Up 3.3-fold Up 2 3-fold
England[b]	Age-adjusted BMI cut-off linked to adult value of 30kg/m^2	4–11	1984(0.6% boys; 1.3% girls)	1994 (1.7% boys; 2.6% girls)	Up 2.8-fold (boys) Up 2.0-fold (girls)
Scotland[c]	Age-adjusted BMI cut-off linked to adult value of 30kg/m^2	4–11	1984 (0.9% boys; 1.8% girls)	1994 (2.1% boys; 3.2% girls)	Up 2.3-fold (boys) Up 1.8-fold (girls)
China[d]	Age-adjusted BMI cut-off linked to adult value of 25kg/m^2	6–9 10–18	1991 (10.5%) 1991 (4.5%)	1997 (11.3%) 1997 (6.2%)	Up 1.1-fold Up 1.4-fold
Japan[e]	>120% of standard weight	10	1970 (<4% boys; =4% girls)	1996(=10% boys; =9% girls)	Up 2.5 fold (boys) Up 2.3-fold (girls)
Egypt[f]	Weight-for-height >2 SD from median	0–5	1978 (2.2%)	1996 (8.6%)	Up 3.9-fold
Australia[g]	Age-adjusted BMI cut-off linked to adult value of 30kg/m^2	7–15	1985 (1.4% boys; 1.2% girls)	1995 (4.7% boys; 5.5% girls)	Up 3.4-fold (boys) Up 4.6-fold (girls)
Ghana[f]	Weight-for-height >2 SD from median	0–3	1988 (0.5%)	1993/94 (1.9%)	Up 3.8-fold
Morocco[f]	Weight-for-height >2 SD from median	0–5	1987 (2.7%)	1992 (6.8%)	Up 2.5-fold
Brazil[d]	Age-adjusted BMI cut-off linked to adult value of 25 kg/m^2	6–9 10–18	1974 (4.9%) 1974 (3.7%)	1997 (174%) 1997 (2.6%)	Up 3.6-fold Up 3.4-fold
Chile[h]	Weight-for-height >2 SD from median	0–6	1985 (4.6%)	1995 (72%)	Up 1.6-fold
Costa Rica[f]	Weight-for-height >2 SD from median	0–6 (1982) 1–7 (1996)	1982 (2.3%)	1996 (6.2%)	Up 2.7-fold

Table 13.5 *(continued)*

Country	*Index of measurement*	*Age of children*	*Date of firs study (% obesity)*	*Date of second study (% obesity)*	*Growth of obesity incidence from first to second study*
Haiti[g]	Weight-for-height >2 SD from median	0–5	1978 (0.8%)	1994/95 (2.8%)	Up 3.5-fold

Sources: a Ebbeling, C. B., Pawlak, D. B. and Ludwig, D. S. (2002) Childhood obesity: Public health crisis, common sense cure, *The Lancet*, vol 360, 10 August, pp473–482; b National Center for Health Statistics (1999) Prevalence of overweight among children and adolescents: United States, 1999–2000, available at www.cdc.gov/nchs/products/pubs/pubd/hestats/overweight99.htm (accessed 29 January 2002); c Chinn, S. and Rona, R. J. (2001) Prevalence and trends in overweight and obesity in three cross-sectional studies of British children, 1974–1994, *BMJ*, vol 322, pp24–26; d Wang, Y., Monteiro, C. and Popkin, B. M. (2002) Trends of obesity and underweight in older children and adolescents in the US, Brazil, China, and Russia, *American Journal of Clinical Nutrition*, vol 75, pp971–977; e Murata, M. (2000) Secular trends in growth and changes in eating patterns of Japanese children, *American Journal of Clinical Nutrition*, vol 72 (suppl), ppl379S–1383S; f deOnis, M. and Blossner, M. (2000) Prevalence and trends of overweight among preschool children in developing countries, *American Journal of Clinical Nutrition*, vol 72, pp1032–1039; g Magarey, A. M., Daniels, L. A. and Boulton,T. J. C. (2001) Prevalence of overweight and obesity in Australian children and adolescents: Reassessment of 1985 and 1995 data against new standard international definitions, *Medical Journal of Australia*, vol 174, pp561–564; h Filozof, C., Gonzalez, C., Sereday, M., Mazza, C. and Braguinsky, J. (2001) Obesity prevalence and trends in Latin American countries, *Obesity Review*, vol 2, pp99–106 above is surely an answer to this position. The costs of what is presented as an 'individual' problem are, in fact, society wide. The ill health that results is paid for either in direct costs or in a societal drag – lost opportunities, inequalities and lost efficiencies. This is why policy makers have to get to grips with obesity and the world's weight problem.

Both obesity and overweight are preventable. At present the debate about obesity is divided about which of three broad strategies of action is the best to address. One strand argues that it is a problem caused by over-consumption (diet and the types of food) and oversupply; another that it is lack of physical activity; and the third that there might be a matter of genetic predisposition. Certainly, the emphasis has to be on changing the environmental determinants that allow obesity to happen. A pioneering analysis by Australian researchers in the mid-1990s proposed that the obesity pandemic could only be explained in 'ecological' terms: Professors Garry Egger and Boyd Swinburn set out environmental determinants such as transport, pricing and supply; they claimed that environmental factors were so powerful in upsetting energy balances that obesity could be viewed as 'a normal response to an abnormal environment'.[69] So finely balanced are caloric intake and physical activity than even slight alterations in their levels can lead to weight gain. Swinburn and Egger assert that no amount of individual exhortation will reduce worldwide obesity;[70,71] transport, neighbourhood layout, home environments, fiscal policies and other alterations of supply chains must be tackled instead.

Calculating the Burden of Diet-related Disease

During the 1990s, world attention was given to calculating the costs of what has been called the 'burden of disease'. Five of the ten leading causes of death in the world's most economically advanced country, the US, were, by the 1980s, diet-related: coronary heart disease, some types of cancer, stroke, diabetes mellitus and atherosclerosis. Another three – cirrhosis of the liver, accidents and suicides – were associated with excessive alcohol intake.[72] Together these diseases were accounting for nearly 1.5 million of the 2.1 million annual deaths in the US. Only two categories in the top ten – chronic obstructive lung disease and pneumonia and influenza – had no food connection.

In a 1990s study published by the World Bank, *The Global Burden of Disease*,[73] the authors Murray and Lopez gave a detailed review of causes of mortality in eight regions of the world. Ischaemic heart disease accounted for 6.26 million deaths. Of these, 2.7 million were in established market economies and formerly socialist economies of Europe; 3.6 million were in developing countries (out of 50.5 million deaths from all causes in 1990). Stroke was the next most common cause of death (4.38 million deaths, almost 3 million in developing countries), closely followed by acute respiratory infections (4.3 million, 3.9 million in developing countries). Other leading causes of death include diarrhoeal disease (almost totally occurring in developing countries), chronic obstructive pulmonary disease, tuberculosis, measles, low birthweight, road-traffic accidents and lung cancer, with only diarrhoea and low birthweight having a diet-related aetiology. They also calculated that cancers caused about 6 million deaths in 1990. About 2.4 million cancer deaths occurred in established market economies and former socialist economies of Europe. By 1990, therefore, there were already 50 per cent more cancer deaths in less developed countries than in developed countries.

For their analysis, Murray and Lopez created a new index they called the DALY, standing for the 'disability adjusted life year'. A DALY is the sum of life years lost owing to premature death, and years lived with disability (adjusted for severity). It is thus a measure of both death and disability (both mortality and morbidity). The top ten DALYs in all developing regions combined already included ischaemic heart disease and cerebovascular disease. Murray and Lopez's report concluded: 'Clearly, the focus of research and debate about health policy in developing regions should address the current challenges presented by the epidemiological transition now, rather than several decades hence.' Table 13.6 gives their original breakdown for the world of the DALYs by main disease, present and anticipated.

The authors anticipated that the greatest increase in cardiovascular disease-related DALYs would occur in developing countries, up from 8.3 per cent in 1990 to 13.8 per cent in 2020 – a rising burden of disease for those countries which could least afford it. The corresponding increase in developed countries' DALYs associated with non-communicable diseases was calculated to be only relatively slight, rising from 20.4 per cent to 22.0 per cent. (The developed world already had a high base rate of DALYs from diet-related disease.) (Interestingly, there is hardly any movement

Table 13.6 *DALYs lost by cause for the developed and developing countries, 1990 and 2020*

Cause	*Developed*		*Developing*	
	1990 (%)	*2020 (%)*	*1990 (%)*	*2020 (%)*
Infectious diseases	7.8	4.3	48.7	22.2
Cardiovascular disease	20.4	22.0	8.3	13.8
Coronary heart disease	9.9	11.2	2.5	5.2
Stroke	5.9	6.2	2.4	4.2
Diabetes	1.9	1.5	0.7	0.7
Cancer	13.7	16.8	4.0	9.0
Neuropsychiatric disorders	22.0	21.8	9.0	13.7
Injuries	14.5	13.0	15.2	21.1

Source: Murray, C. J. L and Lopez, A. D. (1996) *The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases. Injuries and Risk Factors in 1990 and Projected to 2020*. Harvard University Press on behalf of the World Bank and WHO, Cambridge, MA

Table 13.7 *DALYs lost by selected causes for the EU and Australia around 1995*

Cause	*EU* %	*Australia* %
Smoking	9.0	9.5
Alcohol consumption	8.4	2.1
Diet and physical activity	8.3	16.4
Overweight	3.7	2.4
Low fruit and vegetable intake	3.5	2.7
High saturated fat intake	1.1	2.6
Physical inactivity	1.4	6.8

Sources: National Institute of Public Health, Stockholm (1997).[74]

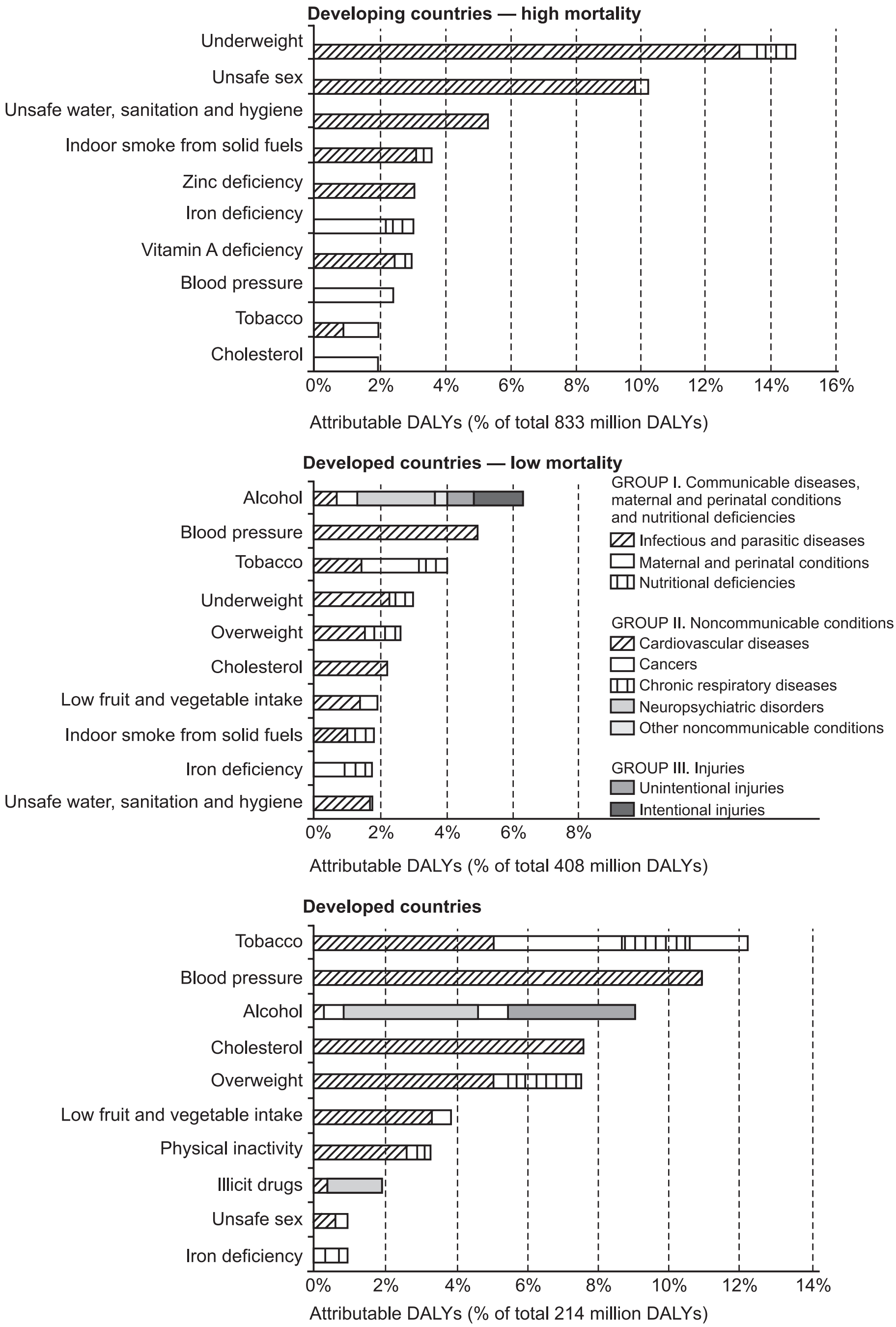
in diabetes figures for developing countries and a fall for developed countries, yet it should be noted that diabetes figures are in fact rising rapidly worldwide. The newness of this diet-related epidemic might have been too late for Murray and Lopez's 1990 data.)

One purpose of the DALY method is to enable policy makers to estimate the relative risk of major factors for health. Table 13.7 gives the Swedish National Institute of Public Health's summary of the calculated impacts of smoking, alcohol, diet and physical activity for key DALYs in the EU and Australia. Again, the diet-related disease toll is very high. Smoking, as was noted at the start of this chapter, is a major contributory factor in heart disease but the dietary factors, when separated, were almost as great.

The DALY approach was extended in the 'World Health Report 2002' which was based on a series of massive multi-country studies designed to test and refine the methodology. Figure 13.11 details risk factors by level of development. The results, however, merely deepened the insights from the earlier study. If anything, the burden of diet-related disease and of lack of physical activity received even higher profile. Special studies on the impact of lack of fruit and vegetables in the diet showed great impact. The WHO–FAO 2003 report underlined how a variety of diseases, from heart disease to diabetes, were all associated with the same dietary pattern: over-consumption, excess fat, under-consumption of fruit and vegetables and excess added sugar and salt.[75]

The Financial Costs

In 2001, the Commission on Macroeconomics and Health, created by the WHO, argued that there were mutual benefits to be had from improved health and for the economy, particularly for those in low-income countries.[76] Table 13.8 shows how general health care costs are rising rapidly in many developed economies; in the developing world, the costs of health care for degenerative diseases are now also



Source: The World Health Report 2002

Figure 13.11 *Burden of disease attributable to ten selected leading risk factors by level of development and type of affected outcome*

Table 13.8 *Growth of expediture on health, 1990–2000*

	Real per capita growth rates, 1990–2000 (%)		*Health spending as per cent of GDP*		
	Health spending	*GDP*	*1990*	*1998*	*2000*
Australia	3.1	2.4	7.8	8.5	8.3
Austria	3.1	1.8	7.1	8.0	8.0
Belgium	3.5	1.8	7.4	8.5	8.7
Canada	1.8	1.7	9.0	9.1	9.1
Czech Republic	3.9	0.1	5.0	7.1	7.2
Denmark	1.7	1.9	8.5	8.4	8.3
Finland	0.1	1.8	7.9	6.9	6.6
France	2.3	1.4	8.6	9.3	9.5
Germany	2.2	0.2	8.7	10.6	10.6
Greece	2.8	1.9	7.5	8.7	8.3
Hungary[a]	2.0	2.7	7.1	6.9	6.8
Iceland	2.9	1.6	7.9	8.3	8.9
Ireland	6.6	6.4	6.6	6.8	6.7
Italy	1.4	1.4	8.0	7.7	8.1
Japan	3.9	1.1	5.9	7.1	7.8
Korea	7.4	5.1	4.8	5.1	5.9
Luxembourg[b]	3.7	4.5	6.1	5.8	6.0
Mexico	3.7	1.6	4.4	5.3	5.4
Netherlands	2.4	2.3	8.0	8.1	8.1
New Zealand	2.9	1.5	6.9	7.9	8.0
Norway	3.5	2.8	7.8	8.5	7.5
Poland[b]	4.8	3.5	5.3	6.4	6.2
Portugal	5.3	2.4	6.2	8.3	8.2
Slovak Republic	—	4.0	—	5.9	5.9
Spain	3.9	2.4	6.6	7.6	7.7
Switzerland	2.5	0.2	8.5	10.6	10.7
UK	3.8	1.9	6.0	6.8	7.3
US	3.2	2.3	11.9	12.9	13.0
OECD Average[c,d]	3.3	2.2	7.2	8.0	8.0
EU Average	3.1	2.3	7.4	8.0	8.0

Notes: No recent estimates are available for Sweden and Turkey. a Hungary: 1991–2000; b Luxembourg and Poland: 1990–1999; c OECD averages exclude the Slovak Republic because of missing 1990 estimates; d Unweighted averages.

Source: OECD (2002) Health Data 2002, available at www.oecd.org/pdf/M00031000/M0Q031130.pdf (pq)

Table 13.9 *Economic costs of diet- and exercise-related health problems, US*

Disease	*Direct costs US$ billion (medical expenditures)*	*Indirect costs US$ billion (productivity losses)*	*Total costs US$ billion*
Heart disease	97.9	77.4	**175.3**
Stroke	28.3	15.0	**43.3**
Arthritis	20.9	62.9	**83.8**
Osteoporosis	n.a.	14.9	**14.9**
Breast cancer	8.3	7.8	**16.1**
Colon cancer	8.1	n.a.	**8.1**
Prostate cancer	5.9	n.a.	**5.9**
Gall bladder disease	6.7	0.6	**7.3**
Diabetes	45.0	55.0	**100.0**
Obesity	55.7	51.4	**107.1**
			Total = 561.8

Note: Costs are expressed in constant 1998 dollars, using the Consumer Price Index.
Source: National Institutes of Health (1998) and Wolf and Colditz (1998)[77]

looming as a serious concern. The growth of health expenditure is sometimes higher than the growth of gross domestic product (GDP). Table 13.9 gives a breakdown of the direct and indirect costs for a number of key diet-related diseases in the US; these costs are immense, even for such a rich society.

Health ministries, it appears, are locked in a model which tends to be curative rather than preventative. The UK health care system, for instance, costs £68 billion for around 60 million people, costs that are anticipated to rise to between £154 billion ($231 billion) and £184 billion ($276 billion) by 2022–2023 in 2002 prices.[78] In other words, at constant prices, UK health care costs are doubling.

In the context of diet-related disease, the direct and indirect financial tolls of ill health could offer opportunities for positive policy intervention through a health-enhancing food supply chain. An estimate for the UK by the Oxford University British Heart Foundation Health Promotion Research Group has calculated that coronary heart disease (CHD) – constituting about half of all cases of cardiovascular disease – costs the UK £10 billion per annum. These costs are made up of £1.6 billion in direct costs (primarily to the taxpayer through the costs of treatment by the NHS) and £8.4 billion in indirect costs to industry, and to society as a whole, through loss of productivity due to death and disability.[79] (This is probably an underestimate of the direct costs to the UK's National Health Service as these costs do not include the cancer treatment costs.)

A report chaired in 2002 by Derek Wanless, a former head of the NatWest Bank, for the Chancellor of the Exchequer produced not dissimilar calculations.[80]

It estimated that costs for the health service will rise alarmingly if targets are not met to reduce CHD and cancers. CHD treatment costs (drugs like statins and surgical techniques like revascularization) would add an additional £2.4 billion per annum by 2010–2011, doubling CHD expenditure. Such calculations remind us of the multi-headed nature of ill health. Smoking, diet, physical activity, genetics, environment and socioeconomic background all have direct health outcomes. Wanless and his team were convinced by US scientific work that high cholesterol – 'which is mainly due to diet' – accounts for 43 per cent of CHD incidence, compared to 20 per cent for smoking. This sort of evidence shows that the poor diet has such far-reaching financial implications that it warrants higher political attention. This case was confirmed by a second Wanless study arguing for the economic value of facing the public health costs of poor diet, life-style and education.[81] However, for the last quarter of a century policy attention has been directed to cutting costs, not by altering the food supply chain, but by such policies as contracting out services and by privatization. In the UK, less than £5 million a year is spent on food-related health education. Meanwhile, drug companies and surgeons only offer expensive but highly sophisticated solutions when the patient is already sick.

Indeed, drug treatments can be hugely expensive. A trial on over 20,000 UK people with high risks for heart disease showed that giving patients a type of drug known as statins reduced the risk of a first coronary attack by 25 per cent but would cost £1 ($1.5) per patient per day.[82] Currently, 1.8 million people are prescribed statins, costing UK£750 million a year. Taking statins for three years can reduce the risk of a heart attack by up to a third.

Coronary Heart Disease (CHD)

Since 1999, the WHO has attributed 30 per cent of all annual global deaths – that is, of 15 million people – to cardiovascular disease.[83,84] The majority of those deaths are in low- and middle-income countries. In 1998, 86 per cent of DALYs were lost to cardiovascular disease (CVD) worldwide.

The main risk factors for heart disease are high blood pressure, smoking and lipid concentrations (cholesterol levels). Others include age, sex, family history and the presence of diabetes. WHO recommendations for reducing CVD include:[85]

- regular physical activity;
- linoleic acid;
- fish and fish oils;
- vegetables and fruits, including berries;
- potassium;
- low to moderate alcohol intake.

The WHO judges that there is convincing evidence for the increasing risks from:

- myristic and palmitic acid;
- trans-fatty acids;
- high sodium intake;
- overweight;
- high alcohol intake.

In regard to CHD, public health policy has tended to focus on two things: health education as prevention, and improved medical treatment through drug, hospital and surgical care. It has also urged behavioural change, in particular a reduction of total fat intake and especially of saturated fats (mainly from animal meat and dairy fats). This health promotion policy has had an effect: rates of heart disease are declining in most affluent Western countries, after years of steady increase since the immediate post-World War II period (see Tables 13.10 and 13.11).[86]

The global picture is more complex, however.[87] For example, the steep rise in CHD in the newly independent countries of Eastern Europe (such as Belarus, Azerbaijan and Hungary) is worrying. Leaving the strictures of the Soviet era means only that already high rates of CHD have risen further. Even in countries considered to have a healthy diet, like Greece and Japan, social change is being accompanied by changing patterns of diet-related disease: Greece's CHD and obesity rates are rising as it changes to a more Northern European diet high in animal fats, following entry to the EU and increased tourism. Death rates from CHD may have dropped in the US and Finland, but it should be remembered that their morbidity and costs are still high, as was shown by the Global Burden of Disease studies.

Table 13.10 *Age-standardized deaths per 100,000 population from CHD selected countries, 1968–1996: men*

Men	*1968*	*1978*	*1988*	*1998*
Finland	718	664	477	340
UK	517	546	434	297
Austria	327	349	262	226
US	694	504	292	224
Australia	674	409	315	202
Canada	543	457	296	200
Italy[a]	230	249	172	150
Belgium[a]	345	313	184	147
Spain	99	165	146	125
France	152	154	118	92
Japan	92	74	52	58

Note: a latest statistics for 1994.

Table 13.11 *Age-standardized deaths per 100,000 population from CHD selected countries, 1968–1996: women*

Women	*1968*	*1978*	*1988*	*1996*
UK	175	182	156	107
Finland	204	177	141	93
US	273	185	119	92
Austria	120	119	84	81
Australia	268	186	117	73
Canada	198	155	100	72
Belgium[a]	111	100	61	46
Italy[a]	87	82	51	43
Spain	33	46	39	34
France	49	44	30	22
Japan	45	99	21	21

Note: a latest statistics for 1994.

Source: British Heart Foundation from WHO country statistics

This complexity keeps epidemiologists busy around the world, but the rapidity of change should bring little surprise. In 1981 Trowell summarized the emergence of CHD amongst East Africans: in the 1930s, he reported, autopsies had shown zero CHD in East Africa, and only one case among 2994 autopsies conducted in Makere University Medical School over the period 1931–1946. However, by the 1960s CHD in this region was emerging as a major rather than peripheral health problem.[88]

In China, between 1991 and 1995,[89] CHD accounted for 15 per cent of all deaths. Cholesterol levels here, compared to those found in Western populations, were low but were increasing rapidly among the urban populations where a more affluent lifestyle was being adopted. Daily intake of meat, eggs and cooking oil had increased while intake of legumes and cereals had decreased. A reduction in the consumption of Western fast foods was also recommended as were increasing physical activity levels, an urging which could be applied to many urbanizing developing countries.

Food-related Cancers

Since the 1980s, dietary factors have been thought to account for around 30 per cent of cancers in Western countries, making diet second only to tobacco as a preventable cause of cancer;[90] in developing countries diet accounted for around 20 per cent.[91] Table 13.12 gives the 1997 review of food-cancer research by the World Cancer Research Fund. An updated report is due out in 2006.

Table 13.12 *Cancers preventable by dietary means*

	Global ranking (incidence)	Global incidence (1000s)	Dietary factors (convincing or probable)	Non-dietary risk factors (established)	Preventable by diet			
					Low estimate (%)	High estimate (%)	Low estimate (1000s)	High estimate (1000s)
Mouth and pharynx	5	575	↓ Vegetables & fruits[a]	? Smoking[a]	33	50	190	288
			↑ alcohol[a]	↑ betel[a]				
Nasopharynx			↑ salted fish[b]	↑ EBV[b]				
Larynx	14	190	↓ Vegetables & fruits ↑ alcohol	↑ Smoking	33	50	63	95
Oesophagus	8	480	↓ Vegetables & fruits	↑ Smoking	50	75	240	360
			↑ deficient diets	↑ Barrett's				
			↑ alcohol	↑ oesophagus				
Lung	1	1320	↓ Vegetables & fruits	↑ Smoking ↑ Occupation	20	33	254	436
Stomach	2	1015	↓ Vegetables & fruits	↑ *H. pylori*	66	75	670	761
			↓ refrigeration					
			↑ salt					
			↑ salted foods					
Pancreas	13	200	↓ Vegetables & fruits ↑ meat, animal fat	↑ Smoking	33	50	66	100
Gallbladder	—	c	—					

Table 13.12 *(continued)*

	Global ranking (incidence)	Global incidence (1000s)	Dietary factors (convincing or probable)	Non-dietary risk factors (established)	Preventable by diet			
					Low estimate (%)	High estimate (%)	Low estimate (1000s)	High estimate (1000s)
Liver	6	540	↑ Alcohol ↑ contaminated food	↑ MBV and HCV	33	66	178	356
Colon, rectum	4	875	↓ Vegetables	↑ Smoking	66	75	578	656
			↓ Physical activity	↑ Genes				
			↑ Meat	↑ Ulcerative colitis				
			↑ Alcohol	↑ *S. sinensis*				
				↓ NSAIDs				
Breast	3	910	↓ Vegetables	↓ Reproductive	33	50	300	455
			↑ Rapid early growth	↑ Genes				
			↑ Early menarche	↑ Radiation				
			↑ Obesity					
			↑ Alcohol					
Ovary	15	190	—	↑ Genes				
				↓ Reproductive	10	20	19	38
Endometrium	16	170	↑ Obesity	↑ OCs				
				↑ Oestrogens				
				↓ Reproductive	25	50	43	85
Cervix	7	525	↓ Vegetables & fruits	↑ HPV	10	20	53	105

Table 13.12 *(continued)*

	Global ranking (incidence)	Global incidence (1000s)	Dietary factors (convincing or probable)	Non-dietary risk factors (established)	Preventable by diet			
					Low estimate (%)	High estimate (%)	Low estimate (1000s)	High estimate (1000s)
				↑ Smoking				
Prostate	9	400	↑ Meat or meat fat or dairy fat		10	20	40	80
Thyroid	—	100[d]	↑ Iodine deficiency	↑ Radiation	10	20	10	20
Kidney	17	165	↑ Obesity	↑ Smoking	25	33	41	54
Bladder	11	310		↑ Phenacetin ↑ Smoking ↑ Occupation ↑ *S. haematobium*	10	20	31	62
Other	2355	—	—		10	10	236	236
Total (1996)	10,320						3022	4187
							29.3%	40.6%

Notes: Included as 'dietary factors' in this table are various foods, nutrients, alcoholic drinks, body weight and physical activity. The panel has estimated the extent to which specific cancers or cancer in general are preventable by the dietary and associated factors described in this report. The figures suggested are ranges consistent with current scientific knowledge, and take established non-dietary risk factors, notably the use of tobacco, specific infections and occupational exposures to carcinogens, into account. The arrows represent either decreasing risk (↓) or increasing risk (↑).
Figures on global ranking and incidence: Parkin et al (1993); WHO (1997).
A mouth and pharynx; also chewing tobacco; b nasopharynx; c reliable worldwide data are not collected by IARC for this site; d conservative estimate based on the IARC (1993).

Source: Table 9.1.2 in World Cancer Research Fund (1997), *Food Nutrition and the Prevention of Cancer: A Global Perspective*. Washington DC: World Cancer Research Fund/American Institute for Cancer Research. Reproduced by permission

The annual WHO World Health Report has shown that cancers are increasing worldwide,[92] and the 2003 World Cancer Report suggested that, like obesity, rising cancer rates are preventable. By virtue of steadily ageing populations, cancer could further increase by 50 per cent to 15 million new cases a year by 2020. In 2000, 6.2 million people died of cancer worldwide (12.5 per cent of all deaths), but 22.4 million were living with cancer. In the South, cancers of the oesophagus, liver and cervix are more common, while in the North, there is a predominance of cancers of the lung, colon, pancreas and breast.

The most significant cause of death among men is lung cancer and among women breast cancer, but certain life-style changes, such as to diet or smoking habits, would alter these patterns. Some cancers are closely associated with diets centred on well-cooked red meats, animal proteins and saturated fats in large quantities, with a daily routine that takes in little physical activity.[93] Indeed, many cancers could be prevented by modifying dietary habits to include more fruits, vegetables, high-fibre cereals, fats and oils derived from vegetables, nuts, seeds and fish, and by limiting the intake of animal fats derived from meat, milk and dairy products.[94,95] A number of published studies show that an increase in antioxidant nutrients such as beta-carotene, vitamins C and E, zinc and selenium could also decrease the risk of certain cancers and there seems to be strong evidence that eating a diet rich in fresh fruit and vegetables will reduce the risk of stomach cancer.[96] Yet the nutrition transition is being driven in a different direction – towards a diet actually higher in processed foods and animal fats, key food industries within the Productionist paradigm.

Diabetes

The incidence of type II diabetes is, alarmingly, on the increase. This form of diabetes was formerly known as non-insulin-dependent diabetes mellitus, occurring when the body is unable to respond to the insulin produced by the pancreas; it accounts for around 90 per cent of cases worldwide. In Type I diabetes (formerly known as insulin-dependent), the pancreas fails to produce the insulin which is essential for survival; this form develops most frequently in children and adolescents, but is now being increasingly noted later in life.[97] It is anticipated that cases of type II diabetes will rise coming years (see Table 13.13): the WHO anticipates a doubling in the number of cases from 150 million in 1997 to 300 million in 2025, with the greatest number of new cases being in China and India.[98]

Diabetes is the fourth main cause of death in most developed countries. Research demonstrates the association between excessive weight gain, central adiposity (fat around the waist) and the development of type II diabetes. Diabetics are two to four times more likely to develop cardiovascular diseases than others, and a stroke is twice as common in people with diabetes and high blood pressure as it is for those with high blood pressure alone. In 2000, India recorded 32.7 million diabetics, China

Table 13.13 *Prevalence of diabetes worldwide*

	2000	*2030*	*Projected growth*
Africa	7020,553	18,244,638	160
Mediterranean	15,189,760	43,483,842	186
Americas	33,014,823	66,828,417	102
European	33,380,754	48,411,977	45
SE Asia	45,810,544	122,023,693	166
Western Pacific	36,138,079	71,685,158	98
Total	171,000,000	366,000,000	114

Source: WHO (2004) *Diabetes Action Programme*. Geneva, World Health Organization, available at www.who.int/diabetes/facts/worid_figures/en/

22.6 million and the US 15.3 million, while Brazil recorded only 3.3 million and Italy 3.1 million. In 2000, the five countries with the highest diabetes prevalence in the adult population only were Papua New Guinea (15.5 per cent), Mauritius (15 per cent), Bahrain (14.8 per cent), Mexico (14.2 per cent) and Trinidad & Tobago (14.1 per cent).[99,100] Such disparate statistics reflect a transition from traditional diet and from an activity-based life-style to a more sedentary one. By 2025, the prevalence of diabetes is anticipated to triple in Africa, the Eastern Mediterranean, the Middle East and South Asia. It is expected to double in the Americas and the Western Pacific and to almost double in Europe. In India, incidence is much higher in urban than rural populations:[101] in urban Chennai (Madras), for example, cases of diabetes rose by 40 per cent in 1988–1994. Incidence is rising among male urban dwellers of South India compared to the rural male population. In addition to diabetes mellitus, the prevalence of NIDDM increased dramatically within the urban populations of India within just a decade.[102] In Thailand, also, NIDDM is more pronounced amongst females in the urban population than it is in the rural population,[103] whilst in the rural environment, incidence of NIDDM amongst males is higher.

In the UK, Professor David Barker and colleagues have shown that adult diabetes is associated with low birthweight,[104] while studies in India suggest that poor interuterine growth, combined with obesity later in life is associated with insulin resistance, diabetes and increased cardiovascular risk.[105] Once again, a single disease seems attributable to a pattern of poor nutrition related to the life cycle, and is one whose costs are externalized onto society as a whole and health care in particular. Devastating complications of diabetes, such as blindness, kidney failure and heart disease, are imposing a huge financial burden: in some countries 5–10 per cent of national health budgets.

Food Safety and Foodborne Diseases

Whilst attention to such non-communicable diseases is of vital importance, food safety, foodborne diseases and other communicable diseases remain uppermost within food and public health policy, partly due to consumer campaigns about risks and to heightened media awareness of poor food processing standards. Food safety problems include risks from:[106]

- veterinary drug and pesticide residues;
- food additives;
- pathogens (i.e. illness-causing bacteria, viruses, parasites, fungi and their toxins);
- environmental toxins such as heavy metals (e.g. lead and mercury);
- persistent organic pollutants such as dioxins;
- unconventional agents such as prions associated with BSE.

In particular, companies have had to respond to new public awareness about food safety issues, and new regimes of traceability have been implemented to enable companies to track food ingredients in order to eliminate subsequent legal or insurance liability consequences. In this respect, food companies are anxious to present themselves as guardians of the public health.[107] The attention food safety receives is predictably higher in affluent countries when, on the evidence, the burden of ill health is far greater in the developing world, due to lack of investment and infrastructure, including drains, housing, water supplies and food control systems. The World Health Report 2002 pointed out that, in developing countries, water supply and general sanitation remain the fourth highest health-risk factor, after underweight, unsafe sex and blood pressure.[108] In developing countries which are building their food export markets, there is too often a bipolar structure, with higher standards for foods for export to affluent countries than for domestic markets. There ought to be a cascading down into internal markets of these higher standards.[109]

Environmental risks to health are a significant problem on the global scale and, in Western countries in the 1990s, new strains of deadly bacteria such as *E. coli 0157* captured policy attention, an estimated 30 per cent of people having suffered a bout of foodborne disease annually. The US, for instance, reports an annual 76 million cases, resulting in 325,000 hospitalizations and 5000 deaths.[110] The WHO estimates that 2.1 million children die every year from the diarrhoeal diseases caused by contaminated water and food,[111,112] asserting that each year worldwide there are 'thousands of millions' of cases of foodborne disease.[113]

In early industrializing countries, a grand era of engineering made dramatic health improvements in public health. Part of that investment included the introduction of effective monitoring and hygiene practice systems, such as the establishment of local authority laboratories and training, the packaging of foods and processes such as milk pasteurization. Today, public health proponents are actively trying to promote a 'second wave' of food safety intervention but this time using a risk-reduction management system known as Hazards Analysis Critical Control Point (HACCP), an approach designed to build safety awareness and control of potential points of hygiene breakdown into food handling and management systems. HACCP also encourages the creation of a 'paper' trail to enable tracking along the production process, essential in order to obviate errors and enable learning. Breakdowns in food safety have in the past led to major political and business crises, with governments under attack and new bodies responsible for food safety being set up in many countries. As food supply chains become more complex and as the scale of production, distribution and mass catering increases, so the chances for problems associated with food contamination rise; mass production breakdowns in food safety spread contamination and pathogens widely. An outbreak of *Salmonellosis* in the US in 1994, for example, affected an estimated 224,000 people.[114] *Listeria monocytogenes* has a fatality rate of 30 per cent, a fact that seriously dented UK public confidence in the 'cook-chill' and 'oven-ready' foods of the late 1980s.

Cross-border trade in agricultural and food products, as well as international pacts have brought food safely to the fore.[115] The Director-General of the WHO, in a speech on food safety to the UN Codex Alimentarius Commission, said: 'globalisation of the world's food supply also means globalisation of public health concerns'.[116] Crises over BSE, *Salmonellosis* and *E. coli*. for example, had had a significant political impact throughout both the UK and EU, for instance,[117] and many countries have experienced a fast rise in incidences of *Salmonellosis* and *Campylobacter* infections since the 1980s, both bacteria being associated with meat and meat products. Despite countries such as Denmark and Sweden having strict policies governing the extermination of flocks and herds found to be carrying *Salmonella*, the incidence continues through the contamination of feedstuffs, and in Denmark in 1998 the percentage of positive flocks with *Campylobacter* was 47.1 per cent.

Thus, in many developed countries with good monitoring systems, the incidence of foodborne disease has in fact risen during the era of the Productionist paradigm: in West Germany cases of infectious *S. enteritis* rose from 11 per 100,000 head of population in 1963 to 193 per 100,000 in 1990;[118] in England and Wales formal notifications of the same disease rose from 14,253 cases in 1982 to 86,528 in 2000. These cases resulted in millions of days lost from work but, fortunately, relatively few deaths.

Bacteria fill gaps left by nature, evolving new strains; but they are constantly evolving even as science combats existing strains. The new food processes and systems of distribution ushered in by the food technology revolution of the second half of the 20th century provided many opportunities for bacteria to develop and colonize new niches. The incidence of *Salmonella* in the UK, for example, first rose, and then, following good monitoring, hygiene intervention and political pressure, fell right back – in two decades.

Table 13.14 gives a list from the WHO of some of the pathogenic organisms that are associated with food and food hygiene: viruses, bacteria, trematodes

Table 13.14 *Some pathogenic organisms associated with public health, which may be transmitted through food*

Bacteria	*Protozoa*
Bacillus cereus	*Cryptosporidium* spp
Brucella spp	*Entamoeba histolyica*
Campylobacter jejuni and *coli*	*Giardia lamblia*
Clostridium botulinum	*Toxoplasma gondii*
Clostridium perfringens	
Escherichia coli (pathogenic strains)	**Trematodes** (flukeworms)
Listeria monocytogenes	*Fascioia hepatica*
Mycobacterium bovis	*Opistorchis felineus*
Salmonella typhi and *paratyphi*	
Salmonella (non-typhi) spp	**Cestodes** (tapeworms)
Shigella spp	*Diphyllobotrium latum*
Staphylococcus aureus	*Echinococcus* spp
Vibrio cholerae	*Taenia solium* and *saginata*
Vibrio parahaemolyticus	
Vibrio fulnificus	**Nematodes** (roundworms)
Yersinia enterocolitica	*Anisakis* spp
	Ascaris lumbricoides
Viruses	*Trichinella spiralis*
Hepatitis A	*Trichuris trichiura*
Norwalk agents	
Poliovirus	
Rotavirus	

Source: WHO European Centre for Health and Environment, Rome, 2000

(flukeworms), cestodes (tapeworms) and nematodes (roundworms), the last three all small worms that can be found either in soil, fish or meats. The first two are concerns in global food trade particularly. In the case of bacteria such as *Listeria monocytogenes*, only 657 cases were reported throughout the EU in 1998;[119] in the same period, deaths from cardiovascular disease in the EU totalled 1.5 million, 42 per cent of all deaths,[120] while, in 1990, diarrhoeal diseases accounted for 11,000 years of life (DALYs) lost out of a total of 22.7 million in Europe; in the same year, cardiovascular disease accounted for 7 million, diabetes for 371,000 and cancer of the colon and rectum for 593,000,[121] and five times as many years of life were lost due to drug addiction than to diarrhoeal diseases.

Despite a low health burden in the developed world, the financial costs of food poisoning can be significant. Estimates in the US suggest that the diseases caused by major pathogens cost up to $35 billion each year in medical costs and lost productivity.[122] Policy makers must be concerned about both foodborne illness and degenerative diseases, the latter of which do not as yet receive sufficient political attention.

Food Poverty in the Western World

Most public health concern about food poverty rightly centres on the developing world, but it is also important to recognize that the impact of food poverty is significant in the developed world. The new era of globalization has unleashed a reconfiguration of social divisions both between and within countries; these social divisions are particularly marked in societies such as the UK and the US which have pursued neoliberal economic policies. Indeed, one review of EU food and health policies estimated that food poverty was far higher in the UK than any other EU country,[123] where inequalities in income and health widened under the Conservative government of 1979–1997. The proportion of people earning less than half the average income grew[124] and the bottom tenth of society experienced a real, not just relative, decline in income and an increase in social health distinctions. This was the converse of the post-World War II years of Keynesian social democratic policies during which inequalities narrowed: lower UK socioeconomic groups now experience a greater incidence of premature and low birthweight babies, and of heart disease, stroke and some cancers in adults. Risk factors such as bottle-feeding, smoking, physical inactivity, obesity, hypertension, and poor diet were clustered in the lower socioeconomic groups[125] whose diet traditionally derives from cheap energy forms such as meat products, full-cream milk, fats, sugars, preserves, potatoes and cereals with little reliance on vegetables, fruit and wholemeal bread. Essential nutrients such as calcium, iron, magnesium, folate and vitamin C are more likely to be ingested by the higher socioeconomic groups:[126,127] their greater purchasing power creates a market for healthier foods such as skimmed milk, wholemeal bread, fruit and other low-fat options. Similarly, in the US, hunger has been a persistent cause of concern for decades and rising during the 1990s when the Census Bureau calculated that 11 million Americans lived in households which were 'food insecure' with a further 23 million living in households which were 'food insecure without hunger' (in other words at risk of hunger).[128] Other US surveys of the time estimated that at least 4 million children aged under 12 were hungry and an additional 9.6 million were at risk of hunger during at least one month of the year. Despite political criticisms of these surveys, further research suggested that even self-reported hunger, at least by adults, is a valid indication of low intakes of required nutrients. It should be noted that, ironically, the US spent over US$25 billion on federal and state programmes to provide extra food for its 25 million citizens in need of nutritional support.[129]

Implications for Policy

This chapter has sketched the bare bones of a highly complex global picture of diet-related health. Over the last half-century, epidemiologists have generated many facts, figures and arguments about the role of food in the creation and prevention of ill health, linking what humans eat with their patterns of disease. They raise a number of important questions: how much of a risk does poor diet pose? What proportion of the known incidence of key diseases like cancer, heart disease, diabetes and microbiological poisoning can be attributed to the food supply? What levels of certainty can be applied to the many studies that have been produced? Is diet a bigger factor than, say, tobacco or genetics? For policy makers, the uncomfortable fact is that the pattern of diet-related diseases summarized in this chapter appears to be closely associated with the Productionist paradigm. Whilst the paradigm had as its objective the need to produce enough to feed people, its harvest of ill health was mainly sown in the name of economic development. Yet the public health message is clear: if diet is inappropriate or inadequate, population ill health will follow. Diet is one of the most alterable factors in human health, but despite strong evidence for intervention, public policy has only implemented lesser measures such as labelling and health education while the supply chain remains legitimized to produce the ingredients of heart disease, cancer, obesity and their diet-related degenerative diseases.

In making these tough assertions, we are aware that to piece together all food research evidence is immensely complex: more research is always needed; scientific understanding inevitably advances and is refined along the way. But surely, there is enough evidence for action. Certainly there is no shortage of reports and studies with which to inform policy. Calling for more research ought not to be an excuse for policy inaction. Policy procrastination is merely poor political prioritization.

Policy attention needs to shift from the overwhelming focus, enshrined in the Productionist paradigm, on under-consumption and under-supply to a new focus on the relationship between the oversupply of certain foodstuffs, excessive marketing and malconsumption, and do so simultaneously within and between countries. Historically, there has been too much focus on public education as the main driver of health delivery; the diet and health messages, while welcome, have not always had the widespread or long-lasting effect that current data suggests is needed. While there have been reductions, for example, in coronary heart disease mortality rates in affluent societies, this is not universally true, and health education as framed in the West may not be universally appropriate. The food supply chain itself must be reframed and must target wider, more health-appropriate goals.

Even rich countries are struggling to provide and fund equitable solutions to problems caused by diet: drugs and surgery, designer health foods, scientific research and public health education. But for developing countries, the majority of humanity, who have even fewer resources and weaker health care infrastructure, the picture is even more desperate. At the heart of the food policy challenge is the need to reinforce the notion of entitlement to food. While the 1948 Universal Declaration of Human Rights asserted the right to food for health for all, even into the new millennium the call is still not being adequately met, and, for humanity's sake, it must now be pursued with more vigour.

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14

Food Politics: How the Food Industry Influences Nutrition and Health

M. Nestle

Introduction: The Food Industry and 'Eat More'

This chapter is from a book about how the food industry influences what we eat and, therefore, our health. That diet affects health is beyond question. The food industry has given us a food supply so plentiful, so varied, so inexpensive and so devoid of dependence on geography or season that all but the very poorest of Americans can obtain enough energy and nutrients to meet biological needs. Indeed, the US food supply is so abundant that it contains enough to feed everyone in the country nearly twice over – even after exports are considered. The overly abundant food supply, combined with a society so affluent that most people can afford to buy more food than they need, sets the stage for competition. The food industry must compete fiercely for every dollar spent on food, and food companies expend extraordinary resources to develop and market products that will sell, regardless of their effect on nutritional status or waistlines. To satisfy stockholders, food companies must convince people to *eat more* of their products or to eat their products instead of those of competitors. They do so through advertising and public relations, of course, but also by working tirelessly to convince government officials, nutrition professionals and the media that their products promote health – or at least do no harm. Much of this work is a virtually invisible part of contemporary culture that attracts only occasional notice.

This book exposes the ways in which food companies use political processes – entirely conventional and nearly always legal – to obtain government and professional support for the sale of their products. Its twofold purpose is to illuminate the extent to which the food industry determines what people eat and to generate much wider discussion of the food industry's marketing methods and use of the political system.

Reprinted from Nestle M. 2002. *Food politics: How the Food Industry Influences Nutrition and Health*. University of California Press, Berkeley. Introductory Chapter, pp1–28.

In my 25 years as a nutrition educator, I have found that food industry practices are discussed only rarely. The reasons for this omission are not difficult to understand. Most of us believe that we choose foods for reasons of personal taste, convenience and cost; we deny that we can be manipulated by advertising or other marketing practices. Nutrition scientists and practitioners typically believe that food companies are genuinely interested in improving health. They think it makes sense to work with the industry to help people improve their diets, and most are outraged by suggestions that food industry sponsorship of research or programmes might influence what they do or say. Most food company officials maintain that any food product can be included in a balanced, varied and moderate diet; they say that their companies are helping to promote good health when they fund the activities of nutrition professionals. Most officials of federal agriculture and health agencies understand that their units are headed by political appointees whose concerns reflect those of the political party in power and whose actions must be acceptable to Congress. Members of Congress, in turn, must be sensitive to the concerns of corporations that help fund their campaigns.

In this political system, the actions of food companies are normal, legal, and thoroughly analogous to the workings of any other major industry – tobacco, for example – in influencing health experts, federal agencies, and Congress.[1] Promoting food raises more complicated issues than promoting tobacco, however, in that food is required for life and causes problems only when consumed inappropriately. As this book will demonstrate, the primary mission of food companies, like that of tobacco companies, is to sell products. Food companies are not health or social service agencies, and nutrition becomes a factor in corporate thinking only when it can help sell food. The ethical choices involved in such thinking are considered all too rarely.

Early in the 20th century, when the principal causes of death and disability among Americans were infectious diseases related in part to inadequate intake of calories and nutrients, the goals of health officials, nutritionists and the food industry were identical – to encourage people to eat more of all kinds of food. Throughout that century, improvements in the US economy affected the way we eat in important ways: we obtained access to foods of greater variety, our diets improved and nutrient deficiencies gradually declined. The principal nutritional problems among Americans shifted to those of *over-nutrition* – eating too much food or too much of certain kinds of food. Overeating causes its own set of health problems; it deranges metabolism, makes people overweight and increases the likelihood of 'chronic' diseases – coronary heart disease, certain cancers, diabetes, hypertension, stroke and others – that now are leading causes of illness and death in any overfed population.

People may believe that the effects of diet on chronic disease are less important than those of cigarette smoking, but each contributes to about one-fifth of annual deaths in the US. Addressing cigarette smoking requires only a single change in behaviour: don't smoke. But because people must eat to survive, advice about dietary improvements is much more complicated: eat this food instead of that food, or eat less. As this book explains, the 'eat less' message is at the root of much of the controversy over nutrition advice. It directly conflicts with food industry demands that people eat more of their products. Thus food companies work hard to oppose and undermine 'eat less' messages.

I first became aware of the food industry as an influence on government nutrition policies and on the opinions of nutrition experts when I moved to Washington DC, in 1986 to work for the Public Health Service. My job was to manage the editorial production of the first – and as yet only – *Surgeon General's Report on Nutrition and Health*, which appeared as a 700-page book in the summer of 1988.[2] This report was an ambitious government effort to summarize the entire body of research linking dietary factors such as fat, saturated fat, cholesterol, salt, sugar and alcohol to leading chronic diseases. My first day on the job, I was given the rules: no matter what the research indicated, the report could not recommend 'eat less meat' as a way to reduce intake of saturated fat, nor could it suggest restrictions on intake of any other category of food. In the industry-friendly climate of the Reagan administration, the producers of foods that might be affected by such advice would complain to their beneficiaries in Congress, and the report would never be published.

This scenario was no paranoid fantasy; federal health officials had endured a decade of almost constant congressional interference with their dietary recommendations. As I discuss in Part I, agency officials had learned to avoid such interference by resorting to euphemisms, focusing recommendations on nutrients rather than on the foods that contain them and giving a positive spin to any restrictive advice about food. Whereas 'eat less beef' called the industry to arms, 'eat less saturated fat' did not. 'Eat less sugar' sent sugar producers right to Congress, but that industry could live with 'choose a diet moderate in sugar'. When released in 1988, the *Surgeon General's Report* recommended 'choose lean meats' and suggested limitations on sugar intake only for people particularly vulnerable to dental cavities.

Subsequent disputes have only reinforced sensitivities to political expediency when formulating advice about diet and health. Political expediency explains in part why no subsequent *Surgeon General's Report* has appeared, even though Congress passed a law in 1990 requiring that one be issued biannually. After ten years of working to develop a *Surgeon General's Report on Dietary Fat and Health* – surely needed to help people understand the endless debates about the relative health consequences of eating saturated, monounsaturated, trans-saturated and total fat – the government abandoned the project, ostensibly because the science base had become increasingly complex and equivocal. A more compelling reason must have been lack of interest in completing such a report in the election year of 2000. Authoritative recommendations about fat intake would have had to include some 'eat less' advice if for no other reason than because fat is so concentrated in calories – it contains 9 calories per gram, compared to 4 each for protein or carbohydrate[3] – and obesity is a major health concern. Because saturated fat and trans-saturated fat raise risks for heart disease, and the principal sources of such fats in American diets are meat, dairy, cooking fats, and fried, fast and processed foods, 'eat less' advice would provoke the producers and sellers of these foods to complain to their friends in Congress.

Since 1988, in my role as chair of an academic department of nutrition, a member of federal advisory committees, a speaker at public and professional meetings, a frequent commentator on nutrition issues to the press, and (on occasion) a consultant to food companies, I have become increasingly convinced that many of the nutritional problems of Americans – not least of them obesity – can be traced to the food industry's imperative to encourage people to *eat more* in order to generate sales and increase income in a highly competitive marketplace. Ambiguous dietary advice is only one result of this imperative. As I explain in Part II, the industry also devotes enormous financial and other resources to lobbying Congress and federal agencies, forming partnerships and alliances with professional nutrition organizations, funding research on food and nutrition, publicizing the results of selected research studies favourable to industry, sponsoring professional journals and conferences, and making sure that influential groups – federal officials, researchers, doctors, nurses, school teachers and the media – are aware of the benefits of their products.

Later sections of the book describe the ways in which such actions affect food issues of particular public interest and debate. Part III reviews the most egregious example of food company marketing practices: the deliberate use of young children as sales targets and the conversion of schools into vehicles for selling 'junk' foods high in calories but low in nutritional value. Part IV explains how the supplement industry manipulated the political process to achieve a sales environment virtually free of government oversight of the content, safety and advertising claims for its products. In Part V, I describe how the food industry markets 'junk' foods as health foods by adding nutrients and calling them 'functional' foods or 'nutraceuticals'. The concluding chapter summarizes the significance of the issues raised by these examples and offers some options for choosing a healthful diet in an overabundant food system. Finally, the Appendix introduces some terms and concepts used in the field of nutrition and discusses issues that help explain why nutrition research is so controversial and so often misunderstood.

Before plunging into these accounts, some context may prove useful. This introduction addresses the principal questions that bear on the matters discussed in this book: What are we supposed to eat to stay healthy? Does diet really matter? Is there a significant gap between what we are supposed to eat and what we do eat? The answers to these questions constitute a basis for examining the central concern of this book: Does the food industry have anything to do with poor dietary practices? As a background for addressing that question, this introduction provides some fundamental facts about today's food industry and its marketing philosophies and strategies, and also points to some common themes that appear throughout the book.

What is a 'Healthy' Diet?

To promote health as effectively as possible, diets must achieve balance: they must provide *enough* energy (calories) and vitamins, minerals and other essential nutrients to prevent deficiencies and support normal metabolism. At the same time, they must not include *excessive* amounts of these and other nutritional factors that might promote development of chronic diseases. Fortunately, the optimal range of intake of most dietary components is quite broad. It is obvious that people throughout the world eat many different foods and follow many different dietary patterns, many of which promote excellent health and longevity. As with other behavioural factors that affect health, diet interacts with individual genetic variation as well as with cultural, economic and geographical factors that affect infant survival and adult longevity. On a *population* basis, the balance between getting enough of the *right* kinds of nutrients and avoiding too much of the *wrong* kinds is best achieved by diets that include large proportions of energy from plant foods – fruits, vegetables and grains.

The longest-lived populations in the world, such as some in Asia and the Mediterranean, traditionally eat diets that are largely plant-based. Such diets tend to be relatively low in calories but high in vitamins, minerals, fibre and other components of plants (phytochemicals) that – acting together – protect against disease. Dietary patterns that best promote health derive most energy from plant foods, considerably less from foods of animal origin (meat, dairy, eggs) and even less from foods high in animal fats and sugars. The *Food Guide Pyramid* of the US Department of Agriculture (USDA) is meant to depict a plant-based diet that promotes optimal health (see Figure 14.1).

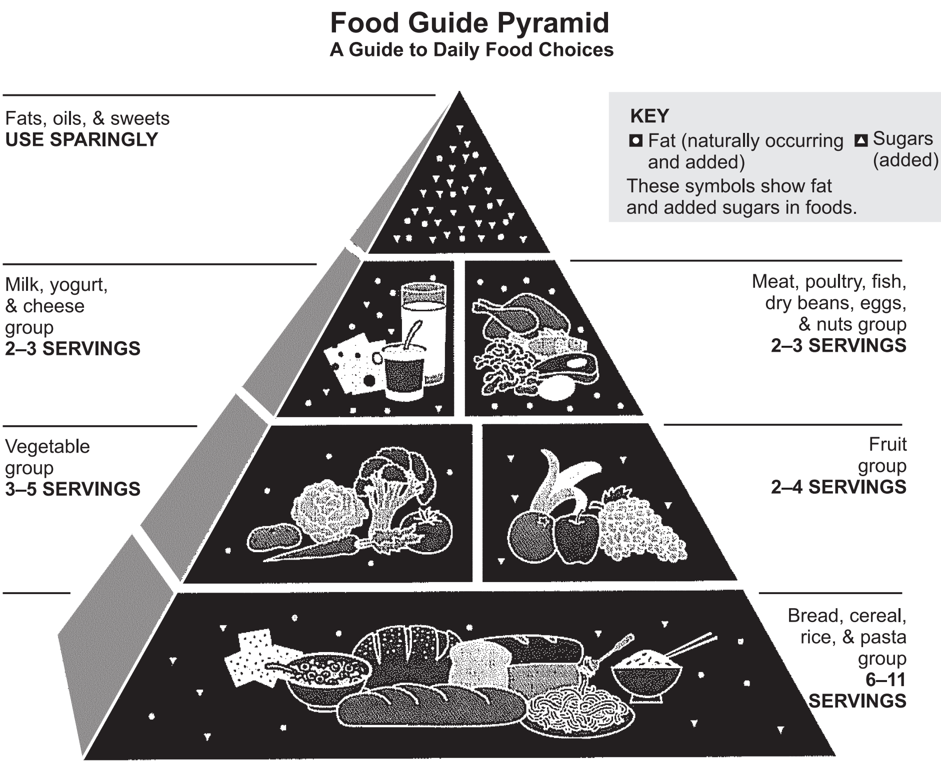


Figure 14.1 *The 1992 USDA Food Guide Pyramid recommends a hierarchical – and therefore controversial – dietary pattern based mainly on foods of plant origin*

Does Diet Matter?

In addition to consuming largely plant-based diets, people in long-lived populations are physically active and burn up any excess calories they obtain from food. An active life-style helps mitigate the harmful effects of overeating, but the evidence for the importance of diet in health also is overwhelming. Disease by chronic disease, scientists consistently have demonstrated the health benefits of diets rich in fruit and vegetables, limited in foods and fats of animal origin and balanced in calories. Comprehensive reports in the late 1980s from the US and Europe documented the evidence available at that time and subsequent research has only strengthened those conclusions.[4]

Health experts suggest conservatively that the combination of poor diet, sedentary life-style and excessive alcohol consumption contributes to about 400,000 of the 2,000,000 or so annual deaths in the US – about the same number and proportion affected by cigarette smoking. Women who follow dietary recommendations display half the rates of coronary heart disease observed among women who eat poor diets, and those who also are active and do not smoke cigarettes have less than one-fifth the risk. The diet-related medical costs for just six health conditions – coronary heart disease, cancer, stroke, diabetes, hypertension and obesity – exceeded $70 billion in 1995. Some authorities believe that just a 1 per cent reduction in intake of saturated fat across the population would prevent more than 30,000 cases of coronary heart disease annually and save more than a billion dollars in health care costs. Such estimates indicate that even small dietary changes can produce large benefits when their effects are multiplied over an entire population.[5]

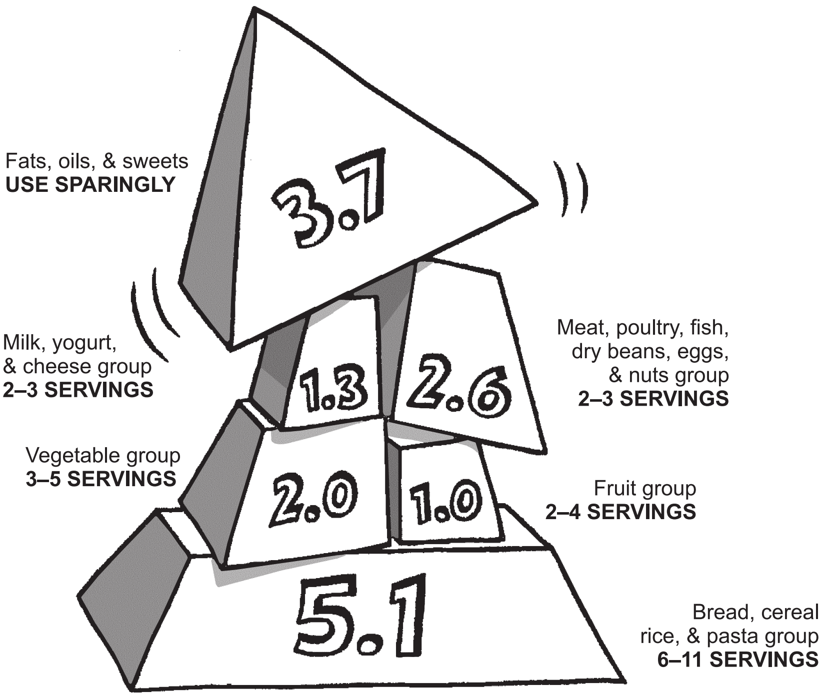
Conditions that can be prevented by eating better diets have roots in childhood. Rates of obesity are now so high among American children that many exhibit metabolic abnormalities formerly seen only in adults. The high blood sugar due to 'adult-onset' (insulin-resistant type II) diabetes, the high blood cholesterol and the high blood pressure now observed in younger and younger children constitute a national scandal. Such conditions increase the risk of coronary heart disease, cancer, stroke and diabetes later in life. From the late 1970s to the early 1990s, the prevalence of *overweight* nearly doubled – from 8 per cent to 14 per cent among children aged 6–11 and from 6 per cent to 12 per cent among adolescents. The proportion of overweight adults rose from 25 per cent to 35 per cent in those years. Just between 1991 and 1998, the rate of adult *obesity* increased from 12 per cent to nearly 18 per cent. Obesity contributes to increased health care costs, thereby becoming an issue for everyone, overweight or not.[6]

The cause of overweight is an excess of calories consumed over calories burned off in activity. People gain weight because they eat too many calories or are too inactive for the calories they eat. Genetics affects this balance, of course, because heredity predisposes some people to gain weight more easily than others, but genetic changes in a population occur too slowly to account for the sharp increase in weight gain over such a short time period. The precise relationship between the diet side and the activity side of the weight 'equation' is uncertain and still under investigation, in part because we lack accurate methods for assessing the activity levels of populations. People seem to be spending more time at sedentary activities such as watching television and staring at computer screens, and the number of hours spent watching television is one of the best predictors of overweight, but surveys do not report enough of a decrease in activity levels to account for the current rising rates of obesity.[7] This gap leaves overeating as the most probable cause of excessive weight gain.

Do Americans Overeat?

Overweight itself constitutes ample evidence that many Americans consume more calories than they burn off, but other sources of information also confirm the idea that people are eating too much food. The calories provided by the US food supply increased from 3,300 per capita in 1970 to 3,800 in the late 1990s, an increase of 500 per day. These supply figures tend to overestimate amounts of food actually consumed because they do not account for wastage, but they do give some indication of trends. Surveys that ask about actual dietary intake tend to underestimate caloric intake, because people find it difficult to remember dietary details but easier to give answers that seem to please investigators. Even so, dietary intake surveys also indicate that people are eating more than they were in the 1970s. Then, people reported eating an average of about 1800 calories per day. By 1996 they reported 2000 calories per day. No matter how unrealistically low these figures may be and how imprecise the sources of data, all suggest a trend toward caloric intakes that exceed average levels of caloric expenditure.[8]

In addition to revealing how much people are eating, food supply and dietary intake surveys indicate changes in food habits over time. The increase in calories reflects an increase in consumption of *all* major food groups: more vegetables and more fruit (desirable), but also more meat and dairy foods, and more foods high in fat and sugar (less desirable). The most pronounced change is in beverage consumption. The supply of whole milk fell from 25.5 gallons per capita per year in 1970 to just 8.5 gallons in 1997. The supply of low-fat milk rose from 5.8 to 15.5 gallons during the same time, but that of soft drinks rose from 24.3 to 53 gallons. To reduce fat intake, people replaced whole milk with lower-fat varieties (same nutrients, fewer calories), but they undermined this beneficial change by increasing consumption of soft drinks (sugar calories, no nutrients). Despite the introduction of artificial sweeteners, the supply of calorie-laden sweeteners – sugars, corn sweeteners and honey – has gone up. Because of the inconsistencies in data, the trend in fat intake is harder to discern. Fat in the food supply increased by 25 per cent from 1970 to the late 1990s, but dietary intake surveys do not find people to be eating more of it. Although USDA nutritionists conclude that Americans are eating less fat, they also observe that people are eating more food outside the home, where foods are higher in fat and calories.[9]



Source: Courtesy National Cattlemen's Beef Association

Figure 14.2 *This 'food consumption' pyramid compares the average number of servings consumed per day by the US population in the mid-1990s to the servings recommended by the Food Guide Pyramid*

In comparison to the *Pyramid*, American diets clearly are out of balance, as shown in Figure 14.2. Top-heavy as it is, this illustration *underestimates* the discrepancy between recommended and actual servings. For one thing, the USDA's serving estimates are based on self-reports of dietary intake, but people tend to underreport the intake of foods considered undesirable and to overestimate the consumption of 'healthy' foods. For another, the USDA calculates numbers of servings by adding up the individual components of mixed dishes and assigning them to the appropriate *Pyramid* categories. This means that the flour in cookies is assigned to the grain category, the apples in pies to the fruit group, and the potatoes in chips to the vegetable group. This method may yield more precise information about nutrient intake, but it makes high-calorie, low-nutrient foods appear as better nutritional choices than they may be. The assignment of the tomatoes in ketchup to the vegetable group only reinforces the absurdity of the USDA's famous attempt during the Reagan administration to count ketchup as a vegetable in the federal school lunch programme.[10]

The comparison hides other unwelcome observations. USDA nutritionists report that the average consumption of whole-grain foods is just one serving per day, well below recommended levels. And although the number of vegetable servings appears close to recommendations, *half* the servings come from just three foods: iceberg lettuce, potatoes (frozen, fresh and those used for chips and fries) and canned tomatoes. When fried potatoes are excluded from the count, vegetable servings fall below three per day. Even though the consumption of reduced-fat dairy products has doubled since 1970, half the dairy servings still come from high-fat, high-calorie cheese and whole milk. Servings of added fats are at least one-third higher than they should be and servings of caloric sweeteners are half again as high. From such observations, we can conclude that the increased calories in American diets come from eating more food in general, but especially more of foods high in fat (meat, dairy, fried foods, grain dishes with added fat), sugar (soft drinks, juice drinks, desserts), and salt (snack foods).[11] It can hardly be a coincidence that these are just the foods that are most profitable to the food industry and that it most vigorously promotes.

The US Food Industry

This book uses the term food industry to refer to companies that produce, process, manufacture, sell and serve foods, beverages and dietary supplements. In a larger sense, the term encompasses the entire collection of enterprises involved in the production and consumption of food and beverages: producers and processors of food crops and animals (agribusiness); companies that make and sell fertilizer, pesticides, seeds and feed; those that provide machinery, labour, real estate and financial services to farmers; and others that transport, store, distribute, export, process and market foods after they leave the farm. It also includes the food service sector – food carts, vending machines, restaurants, bars, fast food outlets, schools, hospitals, prisons and workplaces – and associated suppliers of equipment and serving materials. This vast 'food-and-fiber' system generates a trillion dollars or more in sales every year, accounts for 13 per cent of the US gross national product (GNP) and employs 17 per cent of the country's labour force. Of the $800 billion or so a year that the public spends directly on food and drink, alcoholic beverages account for about $90 billion and the rest is distributed among retail food enterprises (54 per cent) and food service (46 per cent).[12]

The US food industry is the remarkably successful result of 20th-century trends that led from small farms to giant corporations, from a society that cooked at home to one that buys nearly half its meals prepared and consumed elsewhere, and from a diet based on 'whole' foods grown locally to one based largely on foods that have been processed in some way and transported long distances. These changes created a farm system that is much less labour-intensive and far more efficient and specialized. In 1900, 40 per cent of the population lived on farms, but today no more than 2 per cent do. Just since 1960, the number of farms has declined from about 3.2 million to 1.9 million, but their average size has increased by 40 per cent and their productivity by 82 per cent. Most farms today raise just a single commodity such as cattle, chickens, pigs, corn, wheat or soybeans. Many are part of a system of 'vertical' integration: ownership by one corporation of all stages of production and marketing. Chickens constitute an especially clear example. In the mid-1950s, chickens were raised in small flocks by many farmers; today, most are 'factory-farmed' in massive numbers under contract to a few large companies.[13]

Economic pressures force food and beverage companies to expand to tremendous size. In 2000, seven US companies – Philip Morris, ConAgra, Mars, IBP, Sara Lee, Heinz and Tyson Foods – ranked among the ten largest food companies in the world. Nestlé (Switzerland) ranked first, Unilever (UK/Netherlands) third, and Danone (France) sixth. Other US companies such as Coca-Cola, McDonald's, PepsiCo, Procter & Gamble and Roche (vitamins) ranked among the top 100 companies worldwide. In the US alone, just three companies – Philip Morris (Kraft Foods, Miller Brewing), ConAgra and RJR-Nabisco – accounted for nearly 20 per cent of all food expenditures in 1997. Table 14.1 lists the ten leading producers of packaged food products in the US in 2000, along with their annual sales and advertising budgets. The largest companies generated more than $30 billion each in annual sales, placing great pressure on smaller companies to merge. Such pressures also apply to supermarkets. Mergers among food and cigarette companies merit special interest. As described in Table 14.2, two of the four leading US cigarette companies, R. J. Reynolds and Philip Morris, bought – and sometimes swapped – food and beverage companies in manoeuvres designed to protect stockholders' investments against tobacco liability lawsuits.

The increasing consumption of food outside the home also has implications for the food industry – and for health. Table 14.3 lists the leading US food service companies by category: fast foods, restaurant chains, contract corporations and hotel operations. The highest-selling food service chains are sandwich houses and fast food chains. First among them is McDonald's; its 12,804 US outlets brought in $19.6 billion in 2000 sales, more than twice as much as its nearest competitor.

The greater efficiency, specialization and size of agriculture and food product manufacture have led to one of the great unspoken secrets about the American food system: over-abundance. As already noted, the US food supply – plus imports less exports – provides a daily average of 3800 calories per capita. This level is nearly twice the amount needed to meet the energy requirements of most women, one-third more than that needed by most men and much higher than that needed by babies, young children and the sedentary elderly. Even if, as the USDA estimates, 1100 of those calories might be wasted (as spoiled fruit, for example, or as oil for frying potatoes), the excess calories are a major problem for the food industry: they force competition. Even people who overindulge can eat only so much food, and choosing one food means rejecting others. Over-abundance alone is sufficient to explain why the annual growth rate of the American food industry is only a percentage point or two and why it has poked along at that low level for many years. It also explains why food companies compete so strenuously for consumer food dollars,

Table 14.1 *Sales and advertising expenditures for the ten leading producers of packaged food products in the US*

Company and examples	*Food sales [total sales], 1999 ($ billions)*	*Advertising, US, 1998 ($ millions)*
Nestlé	34.9 [49.4]	534.4
Carnation foods		31.1
Lean Cuisine		16.4
Butterfinger candy		11.2
Unilever/Bestfoods *	32.4 [55.3]	
Unilever		1015.0
Lipton's tea beverages		41.8
Wish-Bone salad dressing		15.2
Bestfoods		202.5
Thomas' English muffins		9.5
Skippy peanut butter		4.0
Philip Morris	27.8 [78.6]	2049.3
Kraft Foods, Inc.		146.1
Jell-O desserts		65.6
Altoids mints		10.1
Pepsico	11.6 [18.7]	1263.4
Pepsi and Diet Pepsi		145.2
Lay's potato chips		55.8
Tropicana fruit juices		23.3
Groupe Danone	9.8 [14.2]	*
H.J. Heinz	9.3	214.5
Nabisco	8.4	225.7
Kellogg	7.7	448.5
Cereals		278.7
Eggo frozen waffles		34.3
General Mills*	6.7	597.9
Cereals		296.7
Fruit-by-the-Foot snacks		10.3
Campbell Soup	6.2	336.8
Soups		108.0
Pepperidge Farm		37.2

* In 2000, Unilever purchased Bestfoods soon after acquiring Ben & Jerry's and Slim-Fast. General Mills bought the Pillsbury division of Diageo, making the combined company the fifth largest of US foodmakers, with $12.2 billion in annual sales. Danone was not among the top 200 US advertisers in 1998 because the company's principal markets are in Europe.

Principal Sources: Endicott RC. 44th annual 100 leading national advertisers. *Advertising Age* September 27, 1999: 51–546. Hays CL. *New York Times* June 7, 2000: C1, C8. Thompson S. *Advertising Age* June 12, 2000: 4

Table 14.2 *Cigarette companies' ownership of food and beverage companies: chronology*

1969	Philip Morris, Inc. acquires 53% of Miller Brewing.
1970	Philip Morris buys the remaining 47% of Miller Brewing.
1978	Philip Morris acquires 97% of Seven-Up.
1985	R.J. Reynolds buys Nabisco Foods for $4.9 billion, creating RJR-Nabisco, a public company.
	Philip Morris buys General Foods for $5.6 billion.
1986	Philip Morris sells Seven-Up to PepsiCo.
1988	Philip Morris buys Kraft, Inc. for $13.6 billion. RJR-Nabisco announces plans to 'go private'; offers to buy outstanding public shares for $17 billion.
1989	The investment firm Kohlberg Kravis Roberts leverages a buyout of RJR-Nabisco for $24.9 billion, leaving the private company with $20 billion in debt. Philip Morris combines Kraft and General Foods to form Kraft General Foods.
1990	Philip Morris acquires Jacobs Suchard, a Swiss coffee and confectionary company, for $4.1 billion.
1991	Kohlberg Kravis Roberts sells stocks in RJR-Nabisco to the public. The bestseller *Barbarians at the Gate* (New York: HarperCollins, 1991) describes the takeover events.
1993	Kraft General Foods (Philip Morris) buys Nabisco ready-to-eat cereals from RJR-Nabisco for $448 million.
1995	Kraft General Foods reorganizes into Kraft Foods, Inc. In an effort to shore up stock prices, RJR-Nabisco becomes a holding company for R. J. Reynolds (tobacco) and Nabisco Holdings (food); sells 19% of shares in Nabisco Holdings to the public.
1996	Philip Morris buys shares of Brazil's leading chocolate company, Industrias de Chocolate Lacta, S.A.; Kraft Foods acquires Taco Bell.
1999	RJR-Nabisco sells its international tobacco business; separates and renames its domestic tobacco (R. J. Reynolds Tobacco Holdings) and food businesses (Nabisco Group Holdings). This action leaves Nabisco Group Holdings with 81% of Nabisco as its sole asset (Nabisco Holdings has the remainder), only $1 billion in debt, but with uncertain liability for tobacco lawsuits. Philip Morris said to be interested in buying Nabisco; acquires Philadelphia cream cheese; reports revenues exceeding $78 billion.
2000	Philip Morris buys Nabisco Holdings for $14.9 billion, creating a company that earned combined revenues of $34.9 billion and profits of $5.5 billion in 1999. This purchase leaves R.J. Reynolds Tobacco Holdings with $1.5 billion in cash and the tobacco liability.

Principal Sources: Philip Morris Companies, Inc. Online: www.kraftfoods.com/. Accessed 24 February, 1999. Hays CL. *New York Times* 10 March 1999: A1, C8, and 2 July 2000: C7

why they work so hard to create a sales-friendly regulatory and political climate, and why they are so defensive about the slightest suggestion that their products might raise health or safety risks.

Table 14.3 *Where Americans eat: the top two US food service chain companies in 2000 sales, by category and number of units*

Chain category	*2000 sales, ($ Millions)*	*Number of units, US*
Sandwich		
McDonald's	19,573	12,804
Burger King	8695	8064
Pizza		
Pizza Hut	5000	7927
Domino's	2647	4818
Chicken		
KFC (Kentucky Fried Chicken)	4400	5364
Chick-fil-A	1082	1958
Grill Buffet		
Golden Corral	968	452
Ryan's Family Steak House	745	324
Family		
Denny's	2137	1753
International House of Pancakes	1199	925
Dinner-House		
Applebee's Neighborhood	2625	1251
Red Lobster	2105	629
Contract		
Aramark Global	4136	2907
LSG/Sky Chefs	1476	103
Hotel Food Service		
Marriott	1045	248
Hilton	953	228

Source: Liddle AJ. *Nation's Restaurant News* 25 July 2001: 57–132

Marketing Imperatives

To sell their products, companies appeal to the reasons why people choose to eat one food rather than another. These reasons are numerous, complex and not always understood, mainly because we select diets within the context of the social, economic and cultural environment in which we live. When food or money is scarce, people do not have the luxury of choice; for much of the world's population, the first consideration is getting *enough* food to meet biological needs for energy and nutrients. It is one of the great ironies of nutrition that the traditional plant-based diets consumed by the poor in many countries, some of which are among the world's finest cuisines, are ideally suited to meeting nutritional needs as long as caloric intake is adequate. Once people raised on such foods survive the hazards of infancy, their diets (and their active life-styles) support an adulthood relatively free of chronic disease until late in life.[14]

Also ironic is that once people become better off, they are observed to enter a 'nutrition transition' in which they abandon traditional plant-based diets and begin eating more meat, fat and processed foods. The result is a sharp increase in obesity and related chronic diseases. In 2000 the number of overweight people in the world for the first time matched the number of undernourished people – 1.1 billion each. Even in an industrialized country such as France, dietary changes can be seen to produce rapid increases in the prevalence of chronic disease. In the early 1960s, the French diet contained just 25 per cent of calories from fat, but the proportion now approaches 40 per cent as a result of increased intake of meat, dairy and processed foods. Despite contentions that the French are protected from heart disease by their wine consumption (a phenomenon known as the French Paradox), they are getting fatter by the day and experiencing increased rates of diabetes and other health consequences of overeating and overweight. The nutrition transition reflects both taste preferences and economics. Food animals raised in feedlots eat grains, which makes meat more expensive to produce and converts it into a marker of prosperity. Once people have access to meat, they usually do not return to eating plant-based diets unless they are forced to do so by economic reversal or are convinced to do so for reasons of religion, culture or health.[15]

Humans do not innately know how to select a nutritious diet; we survived in evolution because nutritious foods were readily available for us to hunt or gather. In an economy of over-abundance, food companies can sell products only to people who *want* to buy them. Whether consumer demands drive food sales or the industry creates such demands is a matter of debate, but much industry effort goes into trying to figure out what the public 'wants' and how to meet such 'needs'. Nearly all research on this issue yields the same conclusion. When food is plentiful and people can afford to buy it, basic biological needs become less compelling and the principal determinant of food choice is personal preference. In turn, personal preferences may be influenced by religion and other cultural factors, as well as by considerations of convenience, price and nutritional value. To sell food in an economy of abundant food choices, companies must worry about those other determinants much more than about the nutritional value of their products – unless the nutrient content helps to entice buyers.[16] Thus the food industry's marketing imperatives principally concern four factors: taste, cost, convenience and (as we shall see) public confusion.

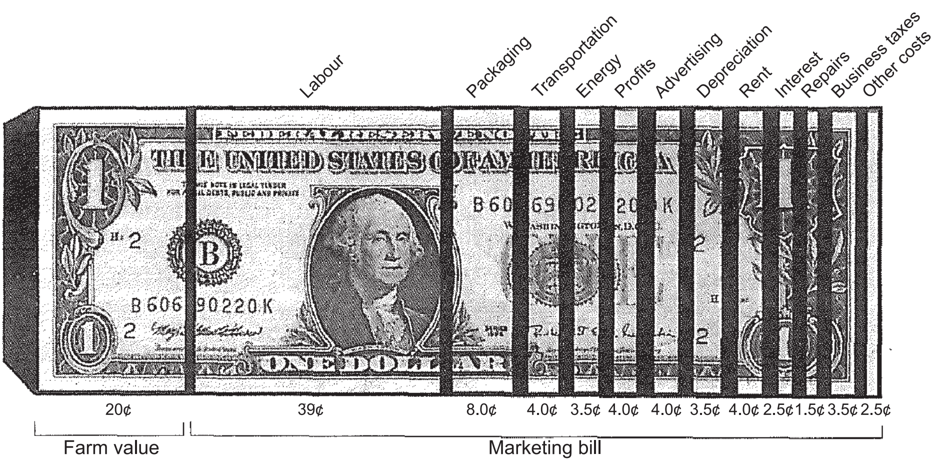
Taste: make foods sweet, fat and salty

Adults prefer foods that taste, look and smell good, are familiar and provide variety, but these preferences are influenced strongly by family and ethnic background, level of education, income, age and gender. When asked, most of us say we choose foods because we like them, by which we mean the way we respond to their flavour, smell, sight and texture. Most of us prefer sweet foods and those that are 'energy-dense' (high in calories, fat and sugar), and we like the taste of salt. The universality of such preferences suggests some physiologic basis for all of them, but the research is most convincing for sweetness. Ripe fruit is innately sweet and appealing, but many of us can and do learn to enjoy the complex and sometimes bitter taste of vegetables. Whether a taste for meat is innate or acquired can be debated, but many people like to eat steak, hamburgers and fried chicken, along with desserts, soft drinks and salty snacks. Such preferences drive the development of new food products as well as the menus in restaurants.

Cost: add value but keep prices low

One result of over-abundance is pressure to add value to foods through processing. The producers of raw foods receive only a fraction of the price that consumers pay at the supermarket. In 1998, for example, an average of 20 per cent of retail cost – the 'farm value' of the food – was returned to its producers. This percentage, which has been declining for years, is unequally distributed. Producers of eggs, beef and chicken receive 50 per cent to 60 per cent of retail cost, whereas producers of vegetables receive as little as 5 per cent. Once foods get to the supermarket, the proportion represented by the farm value declines further in proportion to the extent of processing. The farm value of frozen peas is 13 per cent, of canned tomatoes 9 per cent, of oatmeal 7 per cent and of corn syrup just 4 per cent.[17]

As shown in Figure 14.3, the remaining 80 per cent of the food dollar goes for labour, packaging, advertising and other such value-enhancing activities. Conversion



Source: USDA *FoodReview* 2000; 23(3): 27–30

Figure 14.3 *The distribution of the US food dollar: 80% of food expenditures go to categories other than the 'farm value' of the food itself* of potatoes (cheap) to potato chips (expensive) to those fried in artificial fats or coated in soybean flour or herbal supplements (even more expensive) is an example of how value is added to basic food commodities. Added value explains why the cost of the corn in Kellogg's Corn Flakes is less than 10 per cent of the retail price. With this kind of pricing distribution, food companies are more likely to focus on developing added-value products than to promote consumption of fresh fruits and vegetables, particularly because opportunities for adding value to such foods are limited. Marketers can add value to fruits and vegetables by selling them frozen, canned or pre-cut, but even the most successful of such products – pre-packaged and branded 'baby' carrots, salad mixes and precut fruit – raise consumer concerns about freshness and price.

Despite the focus on adding value, over-abundance keeps food costs low compared to those anywhere else in the world, and this is due only in part to our high average income. The average American pays less than 10 per cent of income for food. People in low-income countries like Tanzania pay more than 70 per cent of income for food and those in middle-income countries like the Philippines up to 55 per cent but even people in high-income countries like Japan pay as much as 20 per cent. Americans, however, strongly resist price increases. In the US, lower prices stimulate sales, especially the sale of higher-cost items; price is a more important factor in the consumer's choice of steak than of ground beef. Cost is so important a factor in food choice that economists are able to calculate the effect of a change in price on nutrient intake. They estimate that a decline in the price of meat, for example, causes the average intake of calcium and iron to rise but also increases the consumption of calories, fat, saturated fat and cholesterol.[18]

A more important reason for low food prices is that the government subsidizes food production in ways that are rarely evident. The most visible subsidies are price supports for sugar and milk, but taxpayers also support production quotas, market quotas, import restrictions, deficiency payments, lower tax rates, low-cost land leases, land management, water rights and marketing and promotion programmes for major food commodities. The total cost of agricultural subsidies rose rapidly at the end of the 20th century from about $18 billion in 1996 to $28 billion in 2000. As we shall see in Part II, the large agricultural corporations that most benefit from federal subsidies spare no effort to persuade Congress and the administration to continue and increase this largesse.[19]

Convenience: make eating fast

Convenience is a principal factor driving the development of value-added products. The demographic causes of demands for convenience are well understood. In the last quarter of the 20th century, the proportion of women with children who entered the work force greatly expanded, and many people began to work longer hours to make ends meet. In 1900, women accounted for 21 per cent of the labour force and married women for less than 6 per cent but by 1999, women – married or not – accounted for more than 60 per cent. The structure of American families changed once there was no longer a housewife who stayed home and cooked.

Working women were unable or unwilling to spend as much time grocery shopping, cooking and cleaning up after meals.[20]

Societal changes easily explain why nearly half of all meals are consumed outside the home, a quarter of them as fast food and the practice of snacking nearly doubled from the mid-1980s to the mid-1990s. They explain the food industry's development of pre-packaged sandwiches, salads, entrees and desserts, as well as such innovations as 'power' bars, yogurt and pasta in tubes, pre-packaged cereal in a bowl, salad bars, hot-food bars, take-out chicken, supermarket 'home meal replacements', McDonald's shaker salads, chips pre-packaged with dips and foods designed to be eaten directly from the package. Whether these 'hyper-convenient' products will outlast the competition remains to be seen, but survival is more likely to depend on taste and price than on nutrient content. Many of these products are high in calories, fat, sugar or salt but are marketed as nutritious because they contain added vitamins.

Nutritionists and traditionalists may lament such developments, because convenience overrides not only considerations of health but also the social and cultural meanings of meals and mealtimes. Many food products relegate cooking to a low-priority chore and encourage trends toward one-dish meals, fewer side dishes, fewer ingredients, larger portions to create leftovers, almost nothing cooked 'from scratch' and home-delivered meals ordered by phone, fax or Internet. Interpreting the meaning of these developments no doubt will occupy sociologists and anthropologists for decades. In the meantime, convenience adds value to foods and stimulates the food industry to create even more products that can be consumed quickly and with minimal preparation.

Confusion: keep the public puzzled

Many people find it difficult to put nutrition advice into practice, not least because they view the advice as ephemeral – changing from one day to the next. This view is particularly unfortunate because advice to eat more fruits and vegetables and to avoid overweight as a means to promote health has remained constant for half a century. Confusion about nutrition is quite understandable, however. People obtain information about diet and health from the media – newspapers, magazines, television, radio and more recently the Internet. These outlets get much of their information from research publications, experts and the public relations representatives of food and beverage companies. Media outlets require *news* and reporters are partial to breakthroughs, simple take-home lessons and controversies. A story about the benefits of single nutrients can be entertaining, but 'eat your veggies' is old news. It is more interesting to read about a study 'proving' that calcium does or does not prevent bone loss than a report that patiently explains the other factors – nutrients, foods, drinks, exercise – that might influence calcium balance in the body. Although foods contain hundreds of nutrients and other components that influence health, and although people eat diets that contain dozens of different foods, reporters rarely discuss study results in their broader dietary context.[21] News outlets are not alone in focusing on single nutrients or foods; researchers also do so. It is easier to study the effects of vitamin E on heart disease risk than it is to try to explain how current dietary *patterns* are associated with declining rates of coronary heart disease. Research on the effects of single nutrients is more likely to be funded and the results are more likely to garner headlines, especially if they conflict with previous studies. In the meantime, basic dietary advice remains the same – constant, but dull.

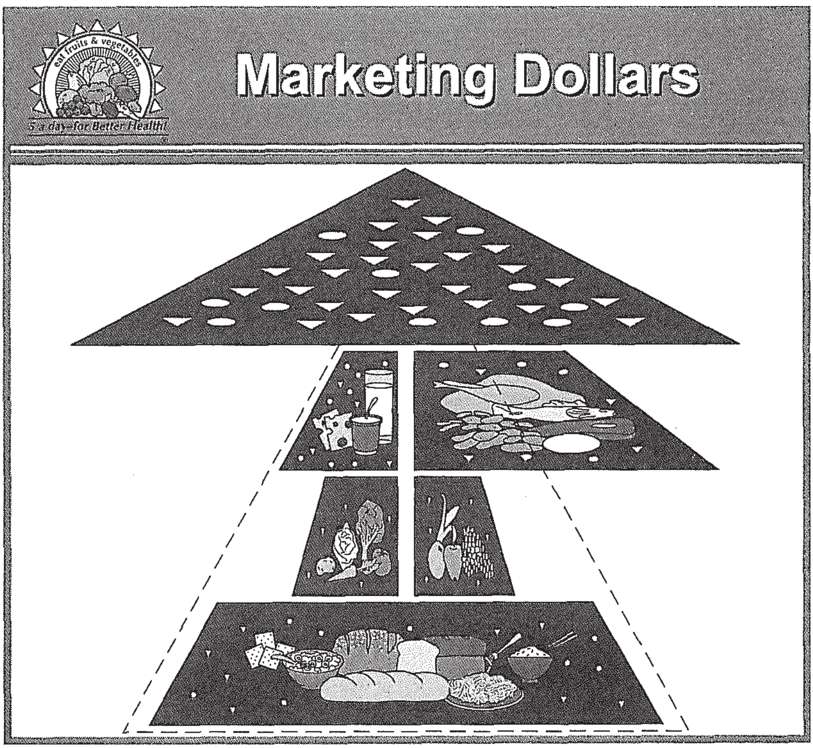
Newspaper sales and research grants may benefit from confusion over dietary advice, but the greatest beneficiary of public confusion is the food industry. Virtually every food and beverage product is represented by a trade association or public relations firm whose job it is to promote a positive image of that item among consumers, professionals and the media. These groups – and their lobbyists – can take advantage of the results of single-nutrient research to claim that products containing the beneficial nutrient promote health and to demand the right to make that claim on package labels. If people are confused about nutrition, they will be more likely to accept such claims at face value. It is in the interest of food companies to have people believe that there is no such thing as a 'good' food (except when it is theirs); that there is no such thing as a 'bad' food (especially not theirs); that all foods (especially theirs) can be incorporated into healthful diets; and that balance, variety and moderation are the keys to healthful diets – which means that no advice to restrict intake of their particular product is appropriate. The *Pyramid*, however, clearly indicates that some foods are better than others from the standpoint of health.

Promoting 'Eat More'

In a competitive food marketplace, food companies must satisfy stockholders by encouraging more people to eat more of their products. They seek new audiences among children, among members of minority groups or internationally. They expand sales to existing as well as new audiences through advertising but also by developing new products designed to respond to consumer 'demands'. In recent years, they have embraced a new strategy: increasing the sizes of food portions. Advertising, new products, and larger portions all contribute to a food environment that promotes eating more, not less.

Advertise, advertise, advertise

Advertising operates so far below the consciousness of everyone – the public, most nutritionists I know and survey researchers – that it hardly ever gets mentioned as an influence on food choice. The subliminal nature of food and beverage advertising is a tribute to its ubiquity, as well as to the sophistication of the agencies that produce it. Extraordinary amounts of money and talent go into this effort. Food and food service companies spend more than $11 billion annually on direct media advertising in magazines, newspapers, radio, television and billboards. Some examples of expenditures by specific companies are given in Table 14.1. In 1999 McDonald's spent $627.2 million, Burger King $403.6 million, Taco Bell $206.5 million and Coke and Diet Coke $174.4 million on direct media advertising. Even small products have impressive advertising budgets, as illustrated by expenditures of $117 million for Wrigley's chewing gum and nearly $80 million for M&M candies.[22] For every dollar spent that 'measured' way, the companies spend another two dollars on discount incentives – for example, coupons for consumers and 'slotting fees' for retailers to ensure space on supermarket shelves. In total, food companies spent more than $33 billion annually at the turn of the century to advertise and promote their products to the public. Most of this astronomical sum is used to promote the most highly processed, elaborately packaged and fast foods. Nearly 70 per cent of food advertising is for convenience foods, candy and snacks, alcoholic beverages, soft drinks and desserts, whereas just 2.2 per cent is for fruits, vegetables, grains or beans.[23] Figure 14.4 illustrates the disproportionate distribu-



Source: Courtesy Elizabeth Pivonka, ©Produce for Better Health Foundation, Wilmington, DE

Figure 14.4 *The Produce for Better Health Foundation, a government–industry partnership to promote consumption of fruits and vegetables, created this 'food marketing' pyramid to illustrate the disproportionate expenditure of advertising dollars in comparison to dietary recommendations* tion of marketing expenditures relative to dietary recommendations. Although the costs of marketing may appear huge, they amount to just a small fraction of sales.

Advertising costs for any single, nationally distributed food product far exceed (often by 10–50 times) federal expenditures for promotion of the *Pyramid* or to encourage people to eat more fruit and vegetables. Of the more than $300 million that the USDA spends annually on nutrition education, most goes for research projects, the educational components of agricultural extension and other activities that target relatively few people. Despite protestations by marketers that advertising is a minor element in food choice and that the ubiquity of advertising dilutes its impact, they continue to use it to sell products. Successful campaigns are carefully researched, targeted to specific groups and repeated frequently. Advertising promotes the sales of specific food products and in proportion to the amount spent, as shown for commodities such as milk, cheese, grapefruit juice and orange juice. Food sales increase with the intensity, repetition and visibility of the advertising message.[24] Promotion of nutritional advantages (low-fat, no cholesterol, high-fibre, calcium-added) increases sales, as does the use of health claims (lowers cholesterol, prevents cancer). Cigarette company-owned food advertisers are particularly adept at using charity to sell food products, as shown in Figure 14.5. Advertising sells food to children, a phenomenon well understood by advertisers of tobacco and beer. Advertisers deliberately promote food brands among children and more active demands for advertised foods.

Introduce new products

To food and beverage companies, added value and convenience are driving forces for new-product development. Whether the industry creates new products in response to consumer demand or generates demand by creating the products is difficult to untangle; most likely, both interact. Regardless, new-product introductions have increased greatly since the mid-1980s when there were fewer than 6000 annually. In the peak year of 1995, manufacturers introduced 16,900 food and beverage products but the number has since declined. All told, 116,000 packaged foods and beverages have been introduced since 1990, and these joined a marketplace that now contains 320,000 items competing for supermarket shelf space large enough to hold just 50,000.[12] The glut of food products means that only the most highly promoted products will succeed; even these may encounter difficulties if they do not taste good, raise questions about health or safety or cost too much.

In 1998, manufacturers introduced slightly more than 11,000 new products (Table 14.4). More than two-thirds of those products are condiments, candy and snacks, baked goods, soft drinks and dairy products (cheese products and ice cream novelties) – foods largely allocated to the top of the *Pyramid*. Slightly more than one-fourth are 'nutritionally enhanced' so that they can be marketed as low in fat, cholesterol, salt or sugar or as higher in fibre, calcium or vitamins. Some such

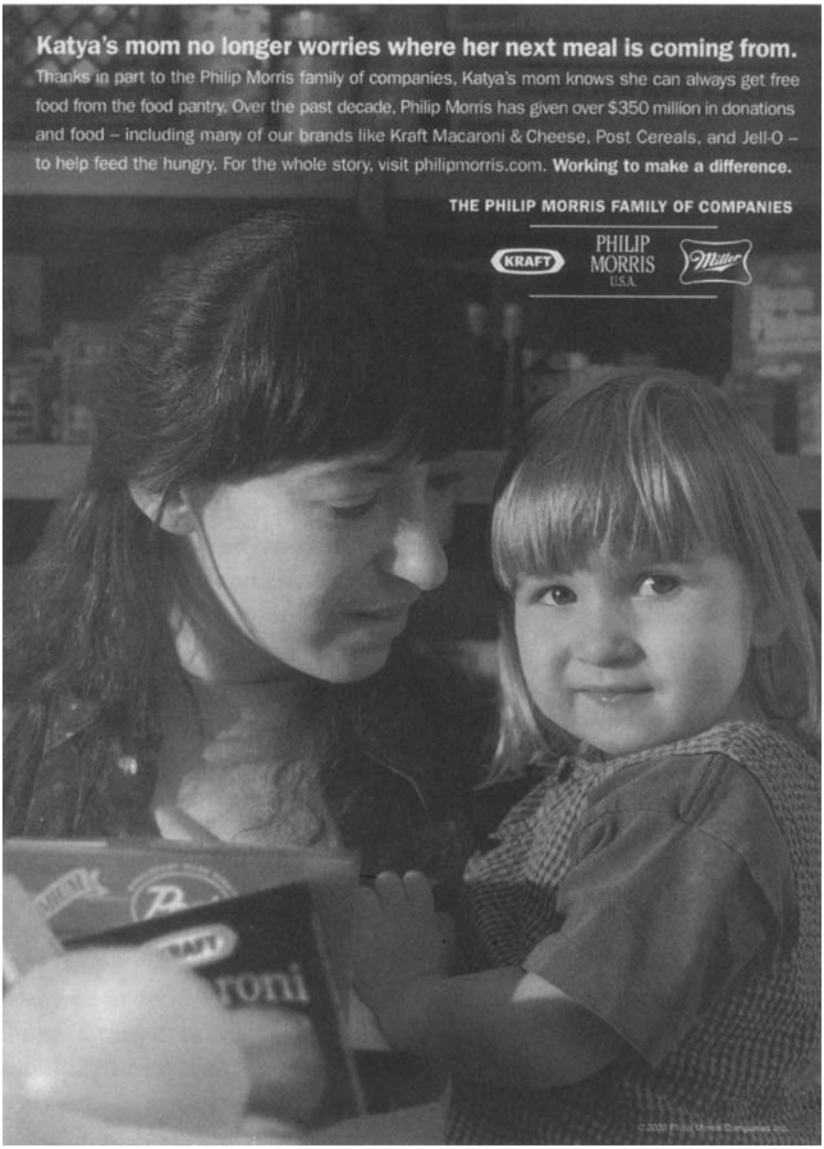


Figure 14.5 *This Philip Morris advertisement for its philanthropic food donations appeared in Walking, a health and fitness magazine aimed at young women, in October 2000. No advertisements for cigarettes appear in the magazine. Philip Morris owns Kraft Foods and Miller Beer*

products, among them no-fat cookies, vitamin-enriched cereals and calcium-fortified juice drinks, contain so much sugar that they belong at the top of the *Pyramid*. Developing such foods has only one purpose: to attract sales.

Table 14.4 *Major categories of the 11,037 new food products introduced in 1998*

Product category	*Number of new products*
Candy, gum, snacks	2065
Condiments	1994
Beverages	1547
Bakery foods	1178
Dairy foods	940
Processed meats	728
Entrees, pre-prepared	678
Fruits and vegetables	375
Soups	299
Desserts	117
Pet foods	105
Breakfast cereals	84
Baby foods	35

Source: Gallo AE. *FoodReview* 1999; 22(3): 27–29

Serve larger portions

'Eat more' marketing methods extend beyond billboards and television commercials; they also include substantial increases in the sizes of food packages and restaurant portions. When the *Pyramid* recommends 6–11 grain servings, these amounts seem impossibly large with reference to restaurant, fast or take-out foods. The *Pyramid* serving numbers, however, refer to portion size *standards* defined by the USDA: a standard grain serving is one slice of white bread, one ounce of ready-to-eat cereals or muffins, or one-half cup of rice or pasta. Therefore, a single bakery muffin weighing 7 ounces, or one medium container of movie-theatre popcorn (16 cups), easily meets or exceeds a day's grain allowances. Larger servings of course contain more calories. The largest movie-theatre soft drink contains 800 calories if not too diluted with ice. Larger portions can contribute to weight gain unless people compensate with diet and exercise. From an industry standpoint, however, larger portions make good marketing sense. The cost of food is low relative to labour and other factors that add value. Large portions attract customers who flock to all-you-can-eat restaurants and order double-scoop ice cream cones because the relative prices discourage the choice of smaller portions. It does not require much mathematical skill to understand that the larger portions of McDonald's french fries are a better buy than the 'small' when they are 40 per cent cheaper per ounce.[25]

Taken together, advertising, convenience, larger portions and (as we shall see) the added nutrients in foods otherwise high in fat, sugar and salt all contribute to an environment that promotes 'eat more'. Because dietary advice affects sales, food companies also conduct systematic, pervasive and unrelenting – but far less apparent –

campaigns to convince government officials, health organizations and nutrition professionals that their products are healthful or harmless, to undermine any suggestion to the contrary, and to ensure that federal *dietary guidelines* and food guides will help promote sales.

Issues and Themes

Over-abundant food and its consequences occur in the context of increasing centralization and globalization of the food industry and of altered patterns of work, welfare and government. The food system is only one aspect of society, but it is unusual in its universality: everyone eats. Because food affects lives as well as livelihoods, the situations discussed in this book generate substantial attention from the industry and the government, as well as from advocates, nutrition and health professionals, the media and the public at large. In this book's discussions of specific topics and incidents, several themes occur. Some of these themes touch on matters central to the functioning of democratic institutions and are worth noting as they emerge in the chapters that follow.

One such theme is the 'paradox of plenty', the term used by historian Harvey Levenstein to refer to the social consequences of food over-abundance, among them the sharp disparities in diet and health between rich and poor.[26] Wealthier people usually are healthier and they choose better diets. They also tend to avoid smoking cigarettes, to drink alcohol in moderation if at all and to be better educated and more physically active. Health habits tend to cluster in patterns, making it difficult to tease out the effects of diet from that of any other behavioural factor. Most paradoxical in the presence of food over-abundance is that large numbers of people in the US and elsewhere do not have enough to eat. The economic expansion of the 20th century differentially favoured people whose income was higher than average and provided much smaller gains for the poor. As noted earlier, when people in developing countries go through a 'nutrition transition', they increase the intake of meat, fat and processed foods, gain weight and develop risk factors for diseases of over-consumption. In the US, low-income groups seem to have about the same nutrient intake as people who are better off, but they choose diets higher in calories, fat, meat and sugar, and they display higher rates of obesity and chronic diseases. The income gap between rich and poor can be explained by the functioning of economic and related educational systems. The gaps in diet and health are economically based, but they also derive in part from the social status attached to certain kinds of food – meat for the poor and health foods for the rich, for example. Food and beverage companies reinforce this gap when they seek new marketing opportunities among minority groups or in low-income neighbourhoods. The alcoholic beverage industry is especially adept in marketing to 'disenfranchised' groups.[27]

A second theme is the conflict between scientific and other kinds of belief systems. Although most scientists view scientific methods – testing hypotheses by controlled experiments – as inherently valid and truthful, we shall see that many people regard science as just one of a number of belief systems of equal validity and importance. Religious beliefs, concerns about animal rights and views of the fundamental nature of society, for example, influence the way people think about food. So do vested interests. Like any other kind of science, nutrition science is more a matter of probabilities than of absolutes and is, therefore, subject to interpretation. Interpretation, in turn, depends on point of view. Government agencies invoke science as a basis for regulatory decisions. Food and supplement companies invoke science to oppose regulations and dietary advice that might adversely affect sales. Advocates invoke science to question the safety of products perceived as undesirable. In contrast, scientists and food producers, who might benefit from promoting research results, nutritional benefits or safety, tend to view other-than-scientific points of view as inherently irrational. Debates about food issues that affect broad aspects of society often focus on scientific proof of safety whether or not safety constitutes the 'real' issue, largely because alternative belief systems cannot be validated by scientific methods.[28]

The third theme constitutes this book's central thesis: diet is a political issue. Because dietary advice affects food sales, and because companies demand a favourable regulatory environment for their products, dietary practices raise political issues that cut right to the heart of democratic institutions. Nearly all of the situations discussed in this book involve struggles over who decides what people should eat and whether a given food is 'healthy'. As a result, they inevitably involve struggles over the way government balances corporate against public interests. Such struggles are fundamental to the functioning of the American political system. They are revealed whenever a company attacks its critics as 'food police' or justifies self-interested actions as a defence of freedom of choice or exclusion of 'Big Brother' government from personal decisions. They are expressed whenever food companies use financial relationships with members of Congress, political leaders and nutrition and health experts to weaken the regulatory ability of federal agencies and whenever they go to court to block unfavourable regulatory decisions. Despite the overwhelmingly greater resources of food companies in defending their own interests we shall see that consumer advocates sometimes can be highly effective in convincing Congress, federal agencies and the courts to take action in the public interest. On that optimistic note, let's begin by tracing the history of federal dietary advice to the public and the ways in which such advice has been influenced by the actions of the food industry.

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15

Your Trusted Friends

E. Schlosser

Before entering the Ray A. Kroc Museum, you have to walk through McStore. Both sit on the ground floor of McDonald's corporate headquarters, located at One McDonald's Plaza in Oak Brook, Illinois. The headquarters building has oval windows and a grey concrete facade – a look that must have seemed space-age when the building opened three decades ago. Now it seems stolid and drab, an architectural relic of the Nixon era. It resembles the American embassy compounds that always used to attract anti-war protesters, student demonstrators, flag burners. The eighty-acre campus of Hamburger University, McDonald's managerial training centre, is a short drive from headquarters. Shuttle buses constantly go back and forth between the campus and McDonald's Plaza, ferrying clean-cut young men and women in khakis who've come to study for their 'Degree in Hamburgerology'. The course lasts two weeks and trains a few thousand managers, executives and franchisees each year. Students from out of town stay at the Hyatt on the McDonald's campus. Most of the classes are devoted to personnel issues, teaching lessons in teamwork and employee motivation, promoting 'a common McDonald's language' and 'a common McDonald's culture'. Three flagpoles stand in front of McDonald's Plaza, the heart of the hamburger empire. One flies the Stars and Stripes, another flies the Illinois state flag and the third flies a bright red flag with golden arches.

You can buy bean-bag McBurglar dolls at McStore, telephones shaped like french fries, ties, clocks, key chains, golf bags and duffel bags, jewellery, baby clothes, lunch boxes, mouse pads, leather jackets, postcards, toy trucks and much more, all of it bearing the stamp of McDonald's. You can buy T-shirts decorated with a new version of the American flag. The fifty white stars have been replaced by a pair of golden arches.

At the back of McStore, past the footsteps of Ronald McDonald stenciled on the floor, past the shelves of dishes and glassware, a bronze bust of Ray Kroc marks the entrance to his museum. Kroc was the founder of the McDonald's Corporation, and his philosophy of QSC and V – Quality, Service, Cleanliness and Value – still guide

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it. The man immortalized in bronze is balding and middle-aged, with smooth cheeks and an intense look in his eyes. A glass display case nearby holds plaques, awards and letters of praise. 'One of the high-lights of my sixty-first birthday celebration', President Richard Nixon wrote in 1974, 'was when Tricia suggested we needed a "break" on our drive to Palm Springs, and we turned in at McDonald's. I had heard for years from our girls that the "Big Mac" was really something special, and while I've often credited Mrs. Nixon with making the best hamburgers in the world, we are both convinced that McDonald's runs a close second... The next time the cook has a night off we will know where to go for fast service, cheerful hospitality – and probably one of the best food buys in America.' Other glass cases contain artifacts of Kroc's life, mementos of his long years of struggle and his twilight as a billionaire. The museum is small and dimly lit, displaying each object with reverence. The day I visited, the place was empty and still. It didn't feel like a traditional museum, where objects are coolly numbered, catalogued and described. It felt more like a shrine.

Many of the exhibits at the Ray A. Kroc Museum incorporate neat technological tricks. Dioramas appear and then disappear when certain buttons are pushed. The voices of Kroc's friends and coworkers – one of them identified as a McDonald's 'vice president of individuality' – boom from speakers at the appropriate cue. Darkened glass cases are suddenly illuminated from within, revealing their contents. An artwork on the wall, when viewed from the left, displays an image of Ray Kroc. Viewed from the right, it shows the letters QSC and V. The museum does not have a life-size, Audio-Animatronic version of McDonald's founder telling jokes and anecdotes. But one wouldn't be out of place. An interactive exhibit called 'Talk to Ray' shows video clips of Kroc appearing on the *Phil Donahue Show,* being interviewed by Tom Snyder and chatting with Reverend Robert Schuller at the altar of Orange County's Crystal Cathedral. 'Talk to Ray' permits the viewer to ask Kroc as many as thirty-six predetermined questions about various subjects; old videos of Kroc supply the answers. The exhibit wasn't working properly the day of my visit. Ray wouldn't take my questions and so I just listened to him repeating the same speeches.

The Disneyesque tone of the museum reflects, among other things, many of the similarities between the McDonald's Corporation and the Walt Disney Company. It also reflects the similar paths of the two men who founded these corporate giants. Ray Kroc and Walt Disney were both from Illinois; they were born a year apart, Disney in 1901, Kroc in 1902; they knew each other as young men, serving together in the same World War I ambulance corps; and they both fled the Midwest and settled in southern California, where they played central roles in the creation of new American industries. The film critic Richard Schickel has described Disney's powerful inner need 'to order, control, and keep clean any environment he inhabited'. The same could easily be said about Ray Kroc, whose obsession with cleanliness and control became one of the hallmarks of his restaurant chain. Kroc cleaned the holes in his mop wringer with a toothbrush.

Kroc and Disney both dropped out of high school and later added the trappings of formal education to their companies. The training school for Disney's theme-park employees was named Disneyland University. More importantly, the two men shared the same vision of America, the same optimistic faith in technology, the same conservative political views. They were charismatic figures who provided an overall corporate vision and grasped the public mood, relying on others to handle the creative and financial details. Walt Disney neither wrote, nor drew the animated classics that bore his name. Ray Kroc's attempts to add new dishes to McDonald's menu – such as Kolacky, a Bohemian pastry and the Hulaburger, a sandwich featuring grilled pineapple and cheese – were unsuccessful. Both men, however, knew how to find and motivate the right talent. While Disney was much more famous and achieved success sooner, Kroc may have been more influential. His company inspired more imitators, wielded more power over the American economy – and spawned a mascot even more famous than Mickey Mouse.

Despite all their success as businessmen and entrepreneurs, as cultural figures and advocates for a particular brand of Americanism, perhaps the most significant achievement of these two men lay elsewhere. Walt Disney and Ray Kroc were masterful salesmen. They perfected the art of selling things to children. And their success led many others to aim marketing efforts at kids, turning America's youngest consumers into a demographic group that is now avidly studied, analysed and targeted by the world's largest corporations.

Walt and Ray

Ray Kroc took the McDonald brothers' Speedee Service System and spread it nationwide, creating a fast food empire. Although he founded a company that came to symbolize corporate America, Kroc was never a buttoned-down corporate type. He was a former jazz musician who'd played at speakeasies – and at a bordello, on at least one occasion – during Prohibition. He was a charming, funny and indefatigable travelling salesman who endured many years of disappointment, a Willy Loman who finally managed to hit it big in his early sixties. Kroc grew up in Oak Park, Illinois, not far from Chicago. His father worked for Western Union. As a high school freshman, Ray Kroc discovered the joys of selling while employed at his uncle's soda fountain. 'That was where I learned you could influence people with a smile and enthusiasm', Kroc recalled in his autobiography, *Grinding It Out*, 'and sell them a sundae when what they'd come for was a cup of coffee.'

Over the years, Kroc sold coffee beans, sheet music, paper cups, Florida real estate, powdered instant beverages called 'Malt-a-Plenty' and 'Shake-a-Plenty', a gadget that could dispense whipped cream or shaving lather, square ice cream scoops and a collapsible table-and-bench combination called 'Fold-a-Nook' that retreated into the wall like a Murphy bed. The main problem with square scoops of ice cream, he found, was that they slid off the plate when you tried to eat them. Kroc used the same basic technique to sell all these things: he tailored his pitch to fit the buyer's tastes. Despite one setback after another, he kept at it, always convinced that success was just around the corner. 'If you believe in it, and you believe in it hard', Kroc later told audiences, 'it's impossible to fail. I don't care what it is – you can get it!'

Ray Kroc was selling milk-shake mixers in 1954 when he first visited the new McDonald's Self-Service Restaurant in San Bernardino. The McDonald brothers were two of his best customers. The Multimixer unit that Kroc sold could make five milk shakes at once. He wondered why the McDonald brothers needed eight of the machines. Kroc had visited a lot of restaurant kitchens, out on the road, demonstrating the Multimixer – and had never seen anything like the McDonald's Speedee Service System. 'When I saw it', he later wrote, 'I felt like some latter-day Newton who'd just had an Idaho potato caromed off his skull.' He looked at the restaurant 'through the eyes of a salesman' and envisioned putting a McDonald's at busy intersections all across the land.

Richard and 'Mac' McDonald were less ambitious. They were clearing $100,000 a year in profits from the restaurant, a huge sum in those days. They already owned a big house and three Cadillacs. They didn't like to travel. They'd recently refused an offer from the Carnation Milk Company, which thought that opening more McDonald's would increase the sales of milk shakes. Nevertheless, Kroc convinced the brothers to sell him the right to franchise McDonald's nationwide. The two could stay at home, while Kroc travelled the country, making them even richer. A deal was signed. Years later Richard McDonald described his first memory of Kroc, a moment that would soon lead to the birth of the world's biggest restaurant chain: 'This little fellow comes in, with a high voice, and says, "hi".'

After finalizing the agreement with the McDonald brothers, Kroc sent a letter to Walt Disney. In 1917 the two men had both lied about their ages to join the Red Cross and see battle in Europe. A long time had clearly passed since their last conversation. 'Dear Walt', the letter said. 'I feel somewhat presumptuous addressing you in this way yet I feel sure you would not want me to address you any other way. My name is Ray A. Kroc... I look over the Company A picture we had taken at Sound Beach, Conn., many times and recall a lot of pleasant memories.' After the warm-up came the pitch: 'I have very recently taken over the national franchise of the McDonald's system. I would like to inquire if there may be an opportunity for a McDonald's in your Disneyland Development.'

Walt Disney sent Kroc a cordial reply and forwarded his proposal to an executive in charge of the theme park's concessions. Disneyland was still under construction, its opening was eagerly awaited by millions of American children, and Kroc may have had high hopes. According to one account, Disney's company asked Kroc to raise the price of McDonald's french fries from ten cents to fifteen cents; Disney would keep the extra nickel as payment for granting the concession; and the story ends with Ray Kroc refusing to gouge his loyal customers. The account seems highly unlikely, a belated effort by someone at McDonald's to put the best spin on a sales pitch that went nowhere. When Disneyland opened in July of 1955 – an event that Ronald Reagan co-hosted for ABC – it had food stands run by Welch's, Stouffer's and Aunt Jemima's, but no McDonald's. Kroc was not yet in their league. His recollection of Walt Disney as a young man, briefly mentioned in *Grinding It Out*, is not entirely flattering. 'He was regarded as a strange duck', Kroc wrote of Disney, 'because whenever we had time off and went out on the town to chase girls, he stayed in camp drawing pictures.'

Whatever feelings existed between the two men, Walt Disney proved in many respects to be a role model for Ray Kroc. Disney's success had come much more quickly. At the age of 21 he'd left the Midwest and opened his own movie studio in Los Angeles. He was famous before turning 30. In *The Magic Kingdom* (1997) Steven Watts describes Walt Disney's efforts to apply the techniques of mass production to Hollywood moviemaking. He greatly admired Henry Ford and introduced an assembly line and a rigorous division of labour at the Disney Studio, which was soon depicted as a 'fun factory'. Instead of drawing entire scenes, artists were given narrowly defined tasks, meticulously sketching and inking Disney characters while supervisors watched them and timed how long it took them to complete each cel. During the 1930s the production system at the studio was organized to function like that of an automobile plant. 'Hundreds of young people were being trained and fitted', Disney explained, 'into a machine for the manufacture of entertainment.'

The working conditions at Disney's factory, however, were not always fun. In 1941 hundreds of Disney animators went on strike, expressing support for the Screen Cartoonists Guild. The other major cartoon studios in Hollywood had already signed agreements with the union. Disney's father was an ardent socialist, and Disney's films had long expressed a populist celebration of the common man. But Walt's response to the strike betrayed a different political sensibility. He fired employees who were sympathetic to the union, allowed private guards to rough up workers on the picket line, tried to impose a phony company union, brought in an organized crime figure from Chicago to rig a settlement and placed a full-page ad in *Variety* that accused leaders of the Screen Cartoonists Guild of being communists. The strike finally ended when Disney acceded to the union's demands. The experience left him feeling embittered. Convinced that communist agents had been responsible for his troubles, Disney subsequently appeared as a friendly witness before the House Un-American Activities Committee, served as a secret informer for the FBI and strongly supported the Hollywood blacklist. During the height of labour tension at his studio, Disney had made a speech to a group of employees, arguing that the solution to their problems rested not with a labour union, but with *a good day's work*. 'Don't forget this', Disney told them, 'it's the law of the universe that the strong shall survive and the weak must fall by the way, and I don't give a damn what idealistic plan is cooked up, nothing can change that.'

Decades later, Ray Kroc used similar language to outline his own political philosophy. Kroc's years on the road as a travelling salesman – carrying his own order forms and sample books, knocking on doors, facing each new customer alone and having countless doors slammed in his face – no doubt influenced his view of humanity. 'Look, it is ridiculous to call this an industry', Kroc told a reporter in 1972, dismissing any high-minded analysis of the fast food business. 'This is not. This is rat eat rat, dog eat dog. I'll kill'em, and I'm going to kill'em before they kill me. You're talking about the American way of survival of the fittest.'

While Disney backed right-wing groups and produced campaign ads for the Republican Party, Kroc remained aloof from electoral politics – with one notable exception. In 1972, Kroc gave $250,000 to President Nixon's re-election campaign, breaking the gift into smaller donations, funnelling the money through various state and local Republican committees. Nixon had every reason to like McDonald's, long before tasting one of its hamburgers. Kroc had never met the president; the gift did not stem from any personal friendship or fondness. That year the fast food industry was lobbying Congress and the White House to pass new legislation – known as the 'McDonald's bill' – that would allow employers to pay 16- and 17-year-old kids wages 20 per cent lower than the minimum wage. Around the time of Kroc's $250,000 donation, McDonald's crew members earned about $1.60 an hour. The sub-minimum wage proposal would reduce some wages to $1.28 an hour.

The Nixon administration supported the McDonald's bill and permitted McDonald's to raise the price of its Quarter Pounders, despite the mandatory wage and price controls restricting other fast food chains. The size and the timing of Kroc's political contribution sparked Democratic accusations of influence peddling. Outraged by the charges, Kroc later called his critics 'sons of bitches'. The uproar left him wary of backing political candidates. Nevertheless, Kroc retained a soft spot for Calvin Coolidge, whose thoughts on hard work and self-reliance were prominently displayed at McDonald's corporate headquarters.

Better Living

Despite a passionate opposition to socialism and to any government meddling with free enterprise, Walt Disney relied on federal funds in the 1940s to keep his business afloat. The animators' strike had left the Disney Studio in a precarious financial condition. Disney began to seek government contracts – and those contracts were soon responsible for 90 per cent of his studio's output. During World War II, Walt Disney produced scores of military training and propaganda films, including *Food Will Win the War, High-Level Precision Bombing* and *A Few Quick Facts About Venereal Disease*. After the war, Disney continued to work closely with top military officials and military contractors, becoming America's most popular exponent of Cold War science. For audiences living in fear of nuclear annihilation, Walt Disney became a source of reassurance, making the latest technical advances seem marvellous and exciting. His faith in the goodness of American technology was succinctly expressed by the title of a film that the Disney Studio produced for Westinghouse Electric: *The Dawn of Better Living*.

Disney's passion for science found expression in 'Tomorrowland', the name given to a section of his theme park and to segments of his weekly television show. Tomorrowland encompassed everything from space travel to the household appliances of the future, depicting progress as a relentless march toward greater convenience for consumers. And yet, from the very beginning, there was a dark side to this Tomorrowland. It celebrated technology without moral qualms. Some of the science it espoused later proved to be not so benign – and some of the scientists it promoted were unusual role models for the nation's children.

In the mid-1950s Wernher von Braun co-hosted and helped produce a series of Disney television shows on space exploration. 'Man in Space' and the other Tomorrowland episodes on the topic were enormously popular and fuelled public support for an American space programme. At the time, von Braun was the US Army's leading rocket scientist. He had served in the same capacity for the German army during World War II. He had been an early and enthusiastic member of the Nazi party, as well as a major in the SS. At least 20,000 slave labourers, many of them Allied prisoners of war, died at Dora-Nordhausen, the factory where von Braun's rockets were built. Less than ten years after the liberation of Dora-Nordhausen, von Braun was giving orders to Disney animators and designing a ride at Disneyland called Rocket to the Moon. Heinz Haber, another key Tomorrowland adviser – and eventually the chief scientific consultant to Walt Disney Productions – spent much of World War II conducting research on high-speed, high-altitude flight for the Luftwaffe Institute for Aviation Medicine. In order to assess the risks faced by German air force pilots, the institute performed experiments on hundreds of inmates at the Dachau concentration camp near Munich. The inmates who survived these experiments were usually killed and then dissected. Haber left Germany after the war and shared his knowledge of aviation medicine with the US Army Air Force. He later co-hosted Disney's 'Man in Space' with von Braun. When the Eisenhower administration asked Walt Disney to produce a show championing the civilian use of nuclear power, Heinz Haber was given the assignment. He hosted the Disney broadcast called 'Our Friend the Atom' and wrote a popular children's book with the same title, both of which made nuclear fission seem fun, instead of terrifying. 'Our Friend the Atom' was sponsored by General Dynamics, a manufacturer of nuclear reactors. The company also financed the atomic submarine ride at Disneyland's Tomorrowland.

The future heralded at Disneyland was one in which every aspect of American life had a corporate sponsor. Walt Disney was the most beloved children's entertainer in the country. He had unrivalled access to impressionable young minds – and other corporations, with other agendas to sell, were eager to come along for the ride. Monsanto built Disneyland's House of the Future, which was made of plastic. General Electric backed the Carousel of Progress, which featured an Audio-Animatronic housewife, standing in her futuristic kitchen, singing about 'a great big beautiful tomorrow'. Richfield Oil offered Utopian fantasies about cars and a ride aptly named Autopia. 'Here you leave Today', said the plaque at the entrance to Disneyland, 'and enter the world of Yesterday, Tomorrow, and Fantasy.'

At first, Disneyland offered visitors an extraordinary feeling of escape; people had never seen anything like it. The great irony, of course, is that Disney's suburban, corporate world of Tomorrow would soon become the Anaheim of Today. Within a decade of its opening, Disneyland was no longer set amid a rural idyll of orange groves, it was stuck in the middle of cheap motels, traffic jams on the Santa

Ana freeway, fast food joints and industrial parks. Walt Disney frequently slept at his small apartment above the firehouse in Disneyland's Main Street, US. By the early 1960s, the hard realities of Today were more and more difficult to ignore, and Disney began dreaming of bigger things, of Disney World, a place even farther removed from the forces he'd helped to unleash, a fantasy that could be even more thoroughly controlled.

Among other cultural innovations, Walt Disney pioneered the marketing strategy now known as 'synergy'. During the 1930s, he signed licensing agreements with dozens of firms, granting them the right to use Mickey Mouse on their products and in their ads. In 1938 *Snow White* proved a turning point in film marketing: Disney had signed 70 licensing deals prior to the film's release. Snow White toys, books, clothes, snacks and records were already for sale when the film opened. Disney later used television to achieve a degree of synergy beyond anything that anyone had previously dared. His first television broadcast, *One Hour in Wonderland* (1950), culminated in a promotion for the upcoming Disney film *Alice in Wonderland*. His first television series, *Disneyland* (1954), provided weekly updates on the construction work at his theme park. ABC, which broadcast the show, owned a large financial stake in the Anaheim venture. Disneyland's other major investor, Western Printing and Lithography, printed Disney books such as *The Walt Disney Story of Our Friend the Atom*. In the guise of televised entertainment, episodes of *Disneyland* were often thinly disguised infomercials, promoting films, books, toys, an amusement park – and, most of all, Disney himself, the living, breathing incarnation of a brand, the man who neatly tied all the other commodities together into one cheerful, friendly, patriotic idea.

Ray Kroc could only dream, during McDonald's tough early years, of having such marketing tools at his disposal. He was forced to rely instead on his wits, his charisma and his instinct for promotion. Kroc believed completely in whatever he sold and pitched McDonald's franchises with an almost religious fervour. He also knew a few things about publicity, having auditioned talent for a Chicago radio station in the 1920s and performed in nightclubs for years. Kroc hired a publicity firm led by a gag writer and a former MGM road manager to get McDonald's into the news. Children would be the new restaurant chain's target customers. The McDonald brothers had aimed for a family crowd and now Kroc improved and refined their marketing strategy. He'd picked the right moment. America was in the middle of a baby boom; the number of children had soared in the decade after World War II. Kroc wanted to create a safe, clean, all-American place for kids. The McDonald's franchise agreement required every new restaurant to fly the Stars and Stripes. Kroc understood that how he sold food was just as important as how the food tasted. He liked to tell people that he was really in show business, not the restaurant business. Promoting McDonald's to children was a clever, pragmatic decision. 'A child who loves our TV commercials', Kroc explained, 'and brings her grandparents to a McDonald's gives us two more customers.'

The McDonald's Corporation's first mascot was Speedee, a winking little chef with a hamburger for a head. The character was later renamed Archie McDonald. Speedy was the name of Alka-Seltzer's mascot, and it seemed unwise to imply any connection between the two brands. In 1960, Oscar Goldstein, a McDonald's franchisee in Washington DC, decided to sponsor *Bozo's Circus*, a local children's television show. Bozo's appearance at a McDonald's restaurant drew large crowds. When the local NBC station cancelled *Bozo's Circus* in 1963, Goldstein hired its star – Willard Scott, later the weatherman on NBC's *Today* show – to invent a new clown who could make restaurant appearances. An ad agency designed the outfit, Scott came up with the name Ronald McDonald and a star was born. Two years later the McDonald's Corporation introduced Ronald McDonald to the rest of the US through a major ad campaign. But Willard Scott no longer played the part. He was deemed too overweight; McDonald's wanted someone thinner to sell its burgers, shakes and fries.

The late-1960s expansion of the McDonald's restaurant chain coincided with declining fortunes at the Walt Disney Company. Disney was no longer alive and his vision of America embodied just about everything that kids of the 1960s were rebelling against. Although McDonald's was hardly a promoter of whole foods and psychedelia, it had the great advantage of seeming new – and there was something trippy about Ronald McDonald, his clothes and his friends. As McDonald's mascot began to rival Mickey Mouse in name recognition, Kroc made plans to create his own Disneyland. He was a highly competitive man who liked, whenever possible, to settle the score. 'If they were drowning to death', Kroc once said about his business rivals, 'I would put a hose in their mouth.' He planned to buy 1500 acres of land northeast of Los Angeles and build a new amusement park there. The park, tentatively called Western World, would have a cowboy theme. Other McDonald's executives opposed the idea, worried that Western World would divert funds from the restaurant business and lose millions. Kroc offered to option the land with his own money, but finally listened to his close advisers and scrapped the plan. The McDonald's Corporation later considered buying Astro World in Houston. Instead of investing in a large theme park, the company pursued a more decentralized approach. It built small Playlands and McDonaldlands all over the US.

The fantasy world of McDonaldland borrowed a good deal from Walt Disney's Magic Kingdom. Don Ament, who gave McDonaldland its distinctive look, was a former Disney set designer. Richard and Robert Sherman – who had written and composed, among other things, all the songs in Disney's *Mary Poppins*, Disneyland's 'It's a Great, Big, Beautiful Tomorrow' and 'It's a Small World, After All' – were enlisted for the first McDonaldland commercials. Ronald McDonald, Mayor McCheese and the other characters in the ads made McDonald's seem like more than just another place to eat. McDonaldland – with its hamburger patch, apple pie trees and Filet-O-Fish fountain – had one crucial thing in common with Disneyland. Almost everything in it was for sale. McDonald's soon loomed large in the imagination of toddlers, the intended audience for the ads. The restaurant chain evoked a series of pleasing images in a youngster's mind: bright colours, a playground, a toy, a clown, a drink with a straw, little pieces of food wrapped up like a present. Kroc had succeeded, like his old Red Cross comrade, at selling something intangible to children, along with their fries.

Kid Kustomers

Twenty-five years ago, only a handful of American companies directed their marketing at children – Disney, McDonald's, candy makers, toy makers, manufacturers of breakfast cereal. Today children are being targeted by phone companies, oil companies and automobile companies, as well as clothing stores and restaurant chains. The explosion in children's advertising occurred during the 1980s. Many working parents, feeling guilty about spending less time with their kids, started spending more money on them. One marketing expert has called the 1980s 'the decade of the child consumer'. After largely ignoring children for years, Madison Avenue began to scrutinize and pursue them. Major ad agencies now have children's divisions and a variety of marketing firms focus solely on kids. These groups tend to have sweet-sounding names: Small Talk, Kid Connection, Kid2Kid, the Gepetto Group, Just Kids, Inc. At least three industry publications – *Youth Market Alert, Selling to Kids* and *Marketing to Kids Report* – cover the latest ad campaigns and market research. The growth in children's advertising has been driven by efforts to increase not just current, but also future, consumption. Hoping that nostalgic childhood memories of a brand will lead to a lifetime of purchases, companies now plan 'cradle-to-grave' advertising strategies. They have come to believe what Ray Kroc and Walt Disney realized long ago – a person's 'brand loyalty' may begin as early as the age of two. Indeed, market research has found that children often recognize a brand logo before they can recognize their own name.

The discontinued Joe Camel ad campaign, which used a hip cartoon character to sell cigarettes, showed how easily children can be influenced by the right corporate mascot. A 1991 study published in the *Journal of the American Medical Association* found that nearly all of America's six-year-olds could identify Joe Camel, who was just as familiar to them as Mickey Mouse. Another study found that one-third of the cigarettes illegally sold to minors were Camels. More recently, a marketing firm conducted a survey in shopping malls across the country, asking children to describe their favorite TV ads. According to the CME KidCom Ad Traction Study II, released at the 1999 Kids' Marketing Conference in San Antonio, Texas, the Taco Bell commercials featuring a talking chihuahua were the most popular fast food ads. The kids in the survey also liked Pepsi and Nike commercials, but their favourite television ad was for Budweiser.

The bulk of the advertising directed at children today has an immediate goal. 'It's not just getting kids to whine', one marketer explained in *Selling to Kids*, 'it's giving them a specific reason to ask for the product.' Years ago sociologist Vance Packard described children as 'surrogate salesmen' who had to persuade other people, usually their parents, to buy what they wanted. Marketers now use different terms to explain the intended response to their ads – such as 'leverage', 'the nudge factor', 'pester power'. The aim of most children's advertising is straightforward: get kids to nag their parents and nag them well.

James U. McNeal, a professor of marketing at Texas A&M University, is considered America's leading authority on marketing to children. In his book *Kids As Cus-*

tomers (1992), McNeal provides marketers with a thorough analysis of 'children's requesting styles and appeals'. He classifies juvenile nagging tactics into seven major categories. A *pleading* nag is one accompanied by repetitions of words like 'please' or 'mom, mom, mom'. A *persistent* nag involves constant requests for the coveted product and may include the phrase 'I'm gonna ask just one more time'. *Forceful* nags are extremely pushy and may include subtle threats, like 'Well, then, I'll go and ask Dad'. *Demonstrative* nags are the most high-risk, often characterized by full-blown tantrums in public places, breath holding, tears, a refusal to leave the store. *Sugar-coated* nags promise affection in return for a purchase and may rely on seemingly heartfelt declarations like 'You're the best dad in the world'. *Threatening* nags are youthful forms of blackmail, vows of eternal hatred and of running away if something isn't bought. *Pity* nags claim the child will be heartbroken, teased or socially stunted if the parent refuses to buy a certain item. 'All of these appeals and styles may be used in combination', McNeal's research has discovered, 'but kids tend to stick to one or two of each that prove most effective … for their own parents.'

McNeal never advocates turning children into screaming, breath-holding monsters. He has been studying 'Kid Kustomers' for more than 30 years and believes in a more traditional marketing approach. 'The key is getting children to see a firm … in much the same way as [they see] mom or dad, grandma or grandpa', McNeal argues. 'Likewise, if a company can ally itself with universal values such as patriotism, national defense, and good health, it is likely to nurture belief in it among children.'

Before trying to affect children's behaviour, advertisers have to learn about their tastes. Today's market researchers not only conduct surveys of children in shopping malls, they also organize focus groups for kids as young as two or three. They analyse children's artwork, hire children to run focus groups, stage slumber parties and then question children into the night. They send cultural anthropologists into homes, stores, fast food restaurants and other places where kids like to gather, quietly and surreptitiously observing the behaviour of prospective customers. They study the academic literature on child development, seeking insights from the work of theorists such as Erik Erikson and Jean Piaget. They study the fantasy lives of young children, then apply the findings in advertisements and product designs.

Dan S. Acuff – the president of Youth Market System Consulting and the author of *What Kids Buy and Why* (1997) – stresses the importance of dream research. Studies suggest that until the age of six, roughly 80 per cent of children's dreams are about animals. Rounded, soft creatures like Barney, Disney's animated characters and the Teletubbies therefore have an obvious appeal to young children. The Character Lab, a division of Youth Market System Consulting, uses a proprietary technique called Character Appeal Quadrant Analysis to help companies develop new mascots. The technique purports to create imaginary characters who perfectly fit the targeted age group's level of cognitive and neurological development.

Children's clubs have for years been considered an effective means of targeting ads and collecting demographic information; the clubs appeal to a child's fundamental need for status and belonging. Disney's Mickey Mouse Club, formed in 1930, was one of the trailblazers. During the 1980s and 1990s, children's clubs proliferated, as corporations used them to solicit the names, addresses, zip codes and personal comments of young customers. 'Marketing messages sent through a club not only can be personalized', James McNeal advises, 'they can be tailored for a certain age or geographical group.' A well-designed and well-run children's club can be extremely good for business. According to one Burger King executive, the creation of a Burger King Kids Club in 1991 increased the sales of children's meals as much as 300 per cent.

The Internet has become another powerful tool for assembling data about children. In 1998 a federal investigation of websites aimed at children found that 89 per cent requested personal information from kids; only 1 per cent required that children obtain parental approval before supplying the information. A character on the McDonald's website told children that Ronald McDonald was 'the ultimate authority in everything'. The site encouraged kids to send Ronald an email revealing their favourite menu item at McDonald's, their favourite book, their favourite sports team – and their name. Fast food websites no longer ask children to provide personal information without first gaining parental approval; to do so is now a violation of federal law, thanks to the Children's Online Privacy Protection Act, which took effect in April of 2000.

Despite the growing importance of the Internet, television remains the primary medium for children's advertising. The effects of these TV ads have long been a subject of controversy. In 1978, the Federal Trade Commission (FTC) tried to ban all television ads directed at children seven years old or younger. Many studies had found that young children often could not tell the difference between television programming and television advertising. They also could not comprehend the real purpose of commercials and trusted that advertising claims were true. Michael Pertschuk, the head of the FTC, argued that children need to be shielded from advertising that preys upon their immaturity. 'They cannot protect themselves', he said, 'against adults who exploit their present-mindedness.'

The FTC's proposed ban was supported by the American Academy of Pediatrics, the National Congress of Parents and Teachers, the Consumers Union and the Child Welfare League, among others. But it was attacked by the National Association of Broadcasters, the Toy Manufacturers of America and the Association of National Advertisers. The industry groups lobbied Congress to prevent any restrictions on children's ads and sued in federal court to block Pertschuk from participating in future FTC meetings on the subject. In April of 1981, three months after the inauguration of President Ronald Reagan, an FTC staff report argued that a ban on ads aimed at children would be impractical, effectively killing the proposal. 'We are delighted by the FTC's reasonable recommendation', said the head of the National Association of Broadcasters.

The Saturday morning children's ads that caused angry debates 20 years ago now seem almost quaint. Far from being banned, TV advertising aimed at kids is now broadcast 24 hours a day, closed-captioned and in stereo. Nickelodeon, the

Disney Channel, the Cartoon Network and the other children's cable networks are now responsible for about 80 per cent of all television viewing by kids. None of these networks existed before 1979. The typical American child now spends about 21 hours a week watching television – roughly one and a half months of TV every year. That does not include the time children spend in front of a screen watching videos, playing video games or using the computer. Outside of school, the typical American child spends more time watching television than doing any other activity except sleeping. During the course of a year, he or she watches more than 30,000 TV commercials. Even the nation's youngest children are watching a great deal of television. About one-quarter of American children between the ages of two and five have a TV in their room.

Perfect Synergy

Although the fast food chains annually spend about $3 billion on television advertising, their marketing efforts directed at children extend far beyond such conventional ads. The McDonald's Corporation now operates more than 8000 playgrounds at its restaurants in the US. Burger King has more than 2000. A manufacturer of 'playlands' explains why fast food operators build these largely plastic structures: 'Playlands bring in children, who bring in parents, who bring in money.' As American cities and towns spend less money on children's recreation, fast food restaurants have become gathering spaces for families with young children. Every month about 90 per cent of American children between the ages of three and nine visit a McDonald's. The seesaws, slides and pits full of plastic balls have proven to be an effective lure. 'But when it gets down to brass tacks', a *Brandweek* article on fast food notes, 'the key to attracting kids is toys, toys, toys.'

The fast food industry has forged promotional links with the nation's leading toy manufacturers, giving away simple toys with children's meals and selling more elaborate ones at a discount. The major toy crazes of recent years – including Pokémon cards, Cabbage Patch Kids and Tamogotchis – have been abetted by fast food promotions. A successful promotion easily doubles or triples the weekly sales volume of children's meals. The chains often distribute numerous versions of a toy, encouraging repeat visits by small children and adult collectors who hope to obtain complete sets. In 1999 McDonald's distributed 80 different types of Furby. According to a publication called *Tomart's Price Guide to McDonald's Happy Meal Collectibles*, some fast food giveaways are now worth hundreds of dollars.

Rod Taylor, a *Brandweek* columnist, called McDonald's 1997 Teenie Beanie Baby giveaway one of the most successful promotions in the history of American advertising. At the time McDonald's sold about 10 million Happy Meals in a typical week. Over the course of ten days in April of 1997, by including a Teenie Beanie Baby with each purchase, McDonald's sold about 100 million Happy Meals. Rarely has a marketing effort achieved such an extraordinary rate of sales among its intended consumers. Happy Meals are marketed to children between the ages of three and nine; within ten days about four Teenie Beanie Baby Happy Meals were sold for every American child in that age group. Not all of those Happy Meals were purchased for children. Many adult collectors bought Teenie Beanie Baby Happy Meals, kept the dolls and threw away the food.

The competition for young customers has led the fast food chains to form marketing alliances not just with toy companies, but with sports leagues and Hollywood studios. McDonald's has staged promotions with the National Basketball Association and the Olympics. Pizza Hut, Taco Bell and KFC signed a three-year deal with the NCAA. Wendy's has linked with the National Hockey League. Burger King and Nickelodeon, Denny's and Major League Baseball, McDonald's and the Fox Kids Network have all formed partnerships that mix advertisements for fast food with children's entertainment. Burger King has sold chicken nuggets shaped like Teletubbies. McDonald's now has its own line of children's videos starring Ronald McDonald. *The Wacky Adventures of Ronald McDonald* is being produced by Klasky-Csupo, the company that makes *Rugrats* and *The Simpsons*. The videos feature the McDonaldland characters and sell for $3.49. 'We see this as a great opportunity', a McDonald's executive said in a press release, 'to create a more meaningful relationship between Ronald and kids.'

All of these cross-promotions have strengthened the ties between Hollywood and the fast food industry. In the past few years, the major studios have started to recruit fast food executives. Susan Frank, a former director of national marketing for McDonald's, later became a marketing executive at the Fox Kids Network. She now runs a new family-oriented cable network jointly owned by Hallmark Entertainment and the Jim Henson Company, creator of the Muppets. Ken Snelgrove, who for many years worked as a marketer for Burger King and McDonald's, now works at MGM. Brad Ball, a former senior vice president of marketing at McDonald's, is now the head of marketing for Warner Brothers. Not long after being hired, Ball told the *Hollywood Reporter* that there was little difference between selling films and selling hamburgers. John Cywinski, the former head of marketing at Burger King, became the head of marketing for Walt Disney's film division in 1996, then left the job to work for McDonald's. Forty years after Bozo's first promotional appearance at a McDonald's, amid all the marketing deals, giveaways and executive swaps, America's fast food culture has become indistinguishable from the popular culture of its children.

In May of 1996, the Walt Disney Company signed a ten-year global marketing agreement with the McDonald's Corporation. By linking with a fast food company, a Hollywood studio typically gains anywhere from $25 million to $45 million in additional advertising for a film, often doubling its ad budget. These licensing deals are usually negotiated on a per-film basis; the 1996 agreement with Disney gave McDonald's exclusive rights to that studio's output of films and videos. Some industry observers thought Disney benefited more from the deal, gaining a steady source of marketing funds. According to the terms of the agreement, Disney characters could never be depicted sitting in a McDonald's restaurant or eating any of the chain's food. In the early 1980s, the McDonald's Corporation had turned away offers to buy Disney; a decade later, McDonald's executives sounded a bit defensive about having given Disney greater control over how their joint promotions would be run. 'A lot of people can't get used to the fact that two big global brands with this kind of credibility can forge this kind of working relationship', a McDonald's executive told a reporter. 'It's about their theme parks, their next movie, their characters, their videos… It's bigger than a hamburger. It's about the integration of our two brands, long term.'

The life's work of Walt Disney and Ray Kroc had come full circle, uniting in perfect synergy. McDonald's began to sell its hamburgers and french fries at Disney's theme parks. The ethos of McDonaldland and of Disneyland, never far apart, have finally become one. Now you can buy a Happy Meal at the Happiest Place on Earth.

The Brand Essence

The best insight into the thinking of fast food marketers comes from their own words. Confidential documents from a recent McDonald's advertising campaign give a clear sense of how the restaurant chain views its customers. The McDonald's Corporation was facing a long list of problems. 'Sales are decreasing', one memo noted. 'People are telling us Burger King and Wendy's are doing a better job of giving … better food at the best price', another warned. Consumer research indicated that future sales in some key areas were at risk. 'More customers are telling us', an executive wrote, 'that McDonald's is a big company that just wants to sell … sell as much as it can.' An emotional connection to McDonald's that customers had formed 'as toddlers' was now eroding. The new radio and television advertising had to make people feel that McDonald's still cared about them. It had to link the McDonald's of today to the one people loved in the past. 'The challenge of the campaign', wrote Ray Bergold, the chain's top marketing executive, 'is to make customers believe that McDonald's is their "Trusted Friend."'

According to these documents, the marketing alliances with other brands were intended to create positive feelings about McDonald's, making consumers associate one thing they liked with another. Ads would link the company's french fries 'to the excitement and fanaticism people feel about the NBA'. The feelings of pride inspired by the Olympics would be used in ads to help launch a new hamburger with more meat than the Big Mac. The link with the Walt Disney Company was considered by far the most important, designed to 'enhance perceptions of Brand McDonald's'. A memo sought to explain the underlying psychology behind many visits to McDonald's: parents took their children to McDonald's because they 'want the kids to love them … it makes them feel like a good parent'. Purchasing something from Disney was the '*ultimate*' way to make kids happy, but it was too expensive to do every day. The advertising needed to capitalize on these feelings, letting parents know that 'ONLY MCDONALD'S MAKES IT EASY TO GET A BIT OF DISNEY MAGIC'. The ads aimed at 'minivan parents' would carry an unspoken message about taking your children to McDonald's: 'It's an easy way to feel like a good parent.'

The fundamental goal of the 'My McDonald's' campaign that stemmed from these proposals was to make a customer feel that McDonald's 'cares about me' and 'knows about me'. A corporate memo introducing the campaign explained: 'The essence McDonald's is embracing is "Trusted Friend" … "Trusted Friend" captures all the goodwill and the unique emotional connection customers have with the McDonald's experience … [Our goal is to make] customers believe McDonald's is their "Trusted Friend." Note: this should be done without using the words "Trusted Friend"… Every commercial [should be] honest … Every message will be in good taste and feel like it comes from a trusted friend.' The words 'trusted friend' were never to be mentioned in the ads because doing so might prematurely 'wear out a brand essence' that could prove valuable in the future for use among different national, ethnic and age groups. Despite McDonald's faith in its trusted friends, the opening page of this memo said in bold red letters: 'ANY UNAUTHORIZED USE OR COPYING OF THIS MATERIAL MAY LEAD TO CIVIL OR CRIMINAL PROSECUTION.'

McTeachers and Coke Dudes

Not satisfied with marketing to children through playgrounds, toys, cartoons, movies, videos, charities and amusement parks, through contests, sweepstakes, games and clubs, via television, radio, magazines and the Internet, fast food chains are now gaining access to the last advertising-free outposts of American life. In 1993 District 11 in Colorado Springs started a nationwide trend, becoming the first public school district in the US to place ads for Burger King in its hallways and on the sides of its school buses. Like other school systems in Colorado, District 11 faced revenue shortfalls, thanks to growing enrolments and voter hostility to tax increases for education. The initial Burger King and King Sooper ad contracts were a disappointment for the district, gaining it just $37,500 a year – little more than $1 per student. In 1996, school administrators decided to seek negotiating help from a professional, hiring Dan DeRose, president of DD Marketing, Inc., of Pueblo, Colorado. DeRose assembled special advertising packages for corporate sponsors. For $12,000, a company got five school-bus ads, hallway ads in all 52 of the district's schools, ads in their school newspapers, a stadium banner, ads over the stadium's public-address system during games and free tickets to high school sporting events.

Within a year, DeRose had nearly tripled District 11's ad revenues. But his greatest success was still to come. In August of 1997, DeRose brokered a ten-year deal that made Coca-Cola the district's exclusive beverage supplier, bringing the schools up to $11 million during the life of the contract (minus DD Marketing's fee). The deal also provided free use of a 1998 Chevy Cavalier to a District 11 high school senior, chosen by lottery, who had good grades and a perfect attendance record.

District 11's marketing efforts were soon imitated by other school districts in Colorado, by districts in Pueblo, Fort Collins, Denver and Cherry Creek. Administrators in Colorado Springs did not come up with the idea of using corporate sponsorship to cover shortfalls in a school district's budget. But they took it to a whole new level, packaging it, systematizing it, leading the way. Hundreds of public school districts across the US are now adopting or considering similar arrangements. Children spend about seven hours a day, 150 days a year, in school. Those hours have in the past been largely free of advertising, promotion and market research – a source of frustration to many companies. Today the nation's fast food chains are marketing their products in public schools through conventional ad campaigns, classroom teaching materials and lunchroom franchises, as well as a number of unorthodox means.

The proponents of advertising in the schools argue that it is necessary to prevent further cutbacks; opponents contend that schoolchildren are becoming a captive audience for marketers, compelled by law to attend school and then forced to look at ads as a means of paying for their own education. America's schools now loom as a potential gold mine for companies in search of young customers. 'Discover your own river of revenue at the schoolhouse gates', urged a brochure at the 1997 Kids Power Marketing Conference. 'Whether it's first-graders learning to read or teenagers shopping for their first car, we can guarantee an introduction of your product and your company to these students in the traditional setting of the classroom.'

DD Marketing, with offices in Colorado Springs and Pueblo, has emerged as perhaps the nation's foremost negotiator of ad contracts for schools. Dan DeRose began his career as the founder of the Minor League Football System, serving in the late 1980s as both a team owner and a player. In 1991, he became athletic director at the University of Southern Colorado in Pueblo. During his first year, he raised $250,000 from corporate sponsors for the school's teams. Before long he was raising millions of dollars to build campus sports facilities. He was good at getting money out of big corporations and formed DD Marketing to use this skill on behalf of schools and nonprofits. Beverage companies and athletic shoe companies had long supported college sports programmes and during the 1980s began to put up the money for new high school scoreboards. Dan DeRose saw marketing opportunities that were still untapped. After negotiating his first Colorado Springs package deal in 1996, he went to work for the Grapevine-Colleyville School District in Texas. The district would never have sought advertising, its deputy superintendent told the *Houston Chronicle*, 'if it weren't for the acute need for funds'. DeRose started to solicit ads not only for the district's hallways, stadiums and buses, but also for its rooftops – so that passengers flying in or out of the nearby Dallas–Forth Worth airport could see them – and for its voicemail systems. 'You've reached Grapevine-Colleyville school district, proud partner of Dr Pepper', was a message that DeRose proposed. Although some people in the district were sceptical about the wild ideas of this marketer from Colorado, DeRose negotiated a $3.4 million dollar exclusive deal between the Grapevine-Colleyville School District and Dr Pepper in June of 1997. And Dr Pepper ads soon appeared on school rooftops.

Dan DeRose tells reporters that his work brings money to school districts that badly need it. By pitting one beverage company against another in bidding wars for exclusive deals, he's raised the prices being offered to schools. 'In Kansas City they were getting 67 cents a kid before', he told one reporter, 'and now they're getting $27.' The major beverage companies do not like DeRose and prefer not to deal with him. He views their hostility as a mark of success. He doesn't think that advertising in the schools will corrupt the nation's children and has little tolerance for critics of the trend. 'There are critics to penicillin', he told the *Fresno Bee*. In the three years following his groundbreaking contract for School District 11 in Colorado Springs, Dan DeRose negotiated agreements for 17 universities and 60 public school systems across the US, everywhere from Greenville, North Carolina, to Newark, New Jersey. His 1997 deal with a school district in Derby, Kansas, included the commitment to open a Pepsi GeneratioNext Resource Center at an elementary school. Thus far, DeRose has been responsible for school and university beverage deals worth more than $200 million. He typically accepts no money upfront, then charges schools a commission that takes between 25 and 35 per cent of the deal's total revenues.

The nation's three major beverage manufacturers are now spending large sums to increase the amount of soda that American children consume. Coca-Cola, Pepsi and Cadbury-Schweppes (the maker of Dr Pepper) control 90.3 per cent of the US market, but have been hurt by declining sales in Asia. Americans already drink soda at an annual rate of about 56 gallons per person – that's nearly 600 12-ounce cans of soda per person. Coca-Cola has set itself the goal of raising consumption of its products in the US by at least 25 per cent a year. The adult market is stagnant; selling more soda to kids has become one of the easiest ways to meet sales projections. 'Influencing elementary school students is very important to soft drink marketers', an article in the January 1999 issue of *Beverage Industry* explained, 'because children are still establishing their tastes and habits.' Eight-year-olds are considered ideal customers; they have about 65 years of purchasing in front of them. 'Entering the schools makes perfect sense', the trade journal concluded.

The fast food chains also benefit enormously when children drink more soda. The chicken nuggets, hamburgers and other main courses sold at fast food restaurants usually have the lowest profit margins. Soda has by far the highest. 'We at McDonald's are thankful', a top executive once told the *New York Times*, 'that people like drinks with their sandwiches.' Today McDonald's sells more Coca-Cola than anyone else in the world. The fast food chains purchase Coca-Cola syrup for about $4.25 a gallon. A medium Coke that sells for $1.29 contains roughly 9 cents' worth of syrup. Buying a large Coke for $1.49 instead, as the cute girl behind the counter always suggests, will add another 3 cents' worth of syrup – and another 17 cents in pure profit for McDonald's.

'Liquid Candy', a 1999 study by the Center for Science in the Public Interest, describes who is not benefiting from the beverage industry's latest marketing efforts: the nation's children. In 1978, the typical teenage boy in the US drank about 7 ounces of soda every day; today he drinks nearly three times that amount, deriving 9 per cent of his daily caloric intake from soft drinks. Soda consumption among teenaged girls has doubled within the same period, reaching an average of 12 ounces a day. A significant number of teenage boys are now drinking five or more cans of soda every day. Each can contains the equivalent of about ten teaspoons of sugar. Coke, Pepsi, Mountain Dew and Dr Pepper also contain caffeine. These sodas provide empty calories and have replaced far more nutritious beverages in the American diet. Excessive soda consumption in childhood can lead to calcium deficiencies and a greater likelihood of bone fractures. Twenty years ago, teenage boys in the US drank twice as much milk as soda; now they drink twice as much soda as milk. Soft-drink consumption has also become commonplace among American toddlers. About one-fifth of the nation's one- and two-year-olds now drink soda. 'In one of the most despicable marketing gambits', Michael Jacobson, the author of 'Liquid Candy' reports, 'Pepsi, Dr Pepper and Seven-Up encourage feeding soft drinks to babies by licensing their logos to a major maker of baby bottles, Munchkin Bottling, Inc.' A 1997 study published in the *Journal of Dentistry for Children* found that many infants were indeed being fed soda in those bottles.

The school marketing efforts of the large soda companies have not gone entirely unopposed. Administrators in San Francisco and Seattle have refused to allow any advertising in their schools. 'It's our responsibility to make it clear that schools are here to serve children, not commercial interests', declared a member of the San Francisco Board of Education. Individual protests have occurred as well. In March of 1998, 1200 students at Greenbrier High School in Evans, Georgia, assembled in the school parking lot, many of them wearing red and white clothing, to spell out the word 'Coke'. It was Coke in Education Day at the school, and a dozen Coca-Cola executives had come for the occasion. Greenbrier High was hoping for a $500 prize, which had been offered to the local high school that came up with the best marketing plan for Coca-Cola discount cards. As part of the festivities, Coke executives had lectured the students on economics and helped them bake a Coca-Cola cake. A photographer was hoisted above the parking lot by a crane, ready to record the human C-O-K-E for posterity. When the photographer started to take pictures, Mike Cameron – a Greenbrier senior, standing amid the letter *C* – suddenly revealed a T-shirt that said 'Pepsi'. His act of defiance soon received nationwide publicity, as did the fact that he was immediately suspended from school. The principal said Cameron could have been suspended for a week for the prank, but removed him from classes for just a day. 'I don't consider this a prank', Mike Cameron told the *Washington Post*. 'I like to be an individual. That's the way I am.'

Most school advertising campaigns are more subtle than Greenbrier High's Coke in Education Day. The spiralling cost of textbooks has led thousands of American school districts to use corporate-sponsored teaching materials. A 1998 study of these teaching materials by the Consumers Union found that 80 per cent were biased, providing students with incomplete or slanted information that favoured the sponsor's products and views. Procter & Gamble's *Decision Earth* programme taught that clear-cut logging was actually good for the environment; teaching aids distributed by the Exxon Education Foundation said that fossil fuels created few environmental problems and that alternative sources of energy were too expensive; a study guide sponsored by the American Coal Foundation dismissed fears of a greenhouse effect, claiming that 'the earth could benefit rather than be harmed from increased carbon dioxide'. The Consumers Union found Pizza Hut's Book It! Program – which awards a free Personal Pan Pizza to children who reach targeted reading levels – to be 'highly commercial'. About 20 million elementary school students participated in Book It! during the 1999–2000 school year; Pizza Hut recently expanded the programme to include a million preschoolers.

Lifetime Learning Systems is the nation's largest marketer and producer of corporate-sponsored teaching aids. The group claims that its publications are used by more than 60 million students every year. 'Now you can enter the classroom through custom-made learning materials created with your specific marketing objectives in mind', Lifetime Learning said in one of its pitches to corporate sponsors. 'Through these materials, your product or point of view becomes the focus of discussions in the classroom', it said in another, '… the centerpiece in a dynamic process that generates long-term awareness and lasting attitudinal change.' The tax cuts that are hampering America's schools have proved to be a marketing bonanza for companies like Exxon, Pizza Hut and McDonald's. The money that these corporations spend on their 'educational' materials is fully tax-deductible.

The fast food chains run ads on Channel One, the commercial television network whose programming is now shown in classrooms, almost every school day, to 8 million of the nation's middle, junior and high school students – a teen audience 50 times larger than that of MTV. The fast food chains place ads with Star Broadcasting, a Minnesota company that pipes Top 40 radio into school hallways, lounges and cafeterias. And the chains now promote their food by selling school lunches, accepting a lower profit margin in order to create brand loyalty. At least 20 school districts in the US have their own Subway franchises; an additional 1500 districts have Subway delivery contracts; and nine operate Subway sandwich carts. Taco Bell products are sold in about 4500 school cafeterias. Pizza Hut, Domino's and McDonald's are now selling food in the nation's schools. The American School Food Service Association estimates that about 30 per cent of the public high schools in the US offer branded fast food. Elementary schools in Fort Collins, Colorado, now serve food from Pizza Hut, McDonald's and Subway on special lunch days. 'We try to be more like the fast food places where these kids are hanging out', a Colorado school administrator told the *Denver Post*. 'We want kids to think school lunch is a cool thing, the cafeteria a cool place, that we're "with it", that we're not institutional…'

The new corporate partnerships often put school officials in an awkward position. The Coca-Cola deal that DD Marketing negotiated for Colorado Springs

School District 11 was not as lucrative as it first seemed. The contract specified annual sales quotas. School District 11 was obligated to sell at least 70,000 cases of Coca-Cola products a year, within the first three years of the contract, or it would face reduced payments by Coke. During the 1997–1998 school year, the district's elementary, middle and high schools sold only 21,000 cases of Coca-Cola products. Cara DeGette, the news editor of the *Colorado Springs Independent*, a weekly newspaper, obtained a memorandum sent to school principals by John Bushey, a District 11 administrator. On 28, September 1998, at the start of the new school year, Bushey warned the principals that beverage sales were falling short of projections and that as a result school revenues might be affected. Allow students to bring Coke products into the classrooms, he suggested; move Coke machines to places where they would be accessible to students all day. 'Research shows that vendor purchases are closely linked to availability', Bushey wrote. 'Location, location, location is the key.' If the principals felt uncomfortable allowing kids to drink Coca-Cola during class, he recommended letting them drink the fruit juices, teas and bottled waters also sold in the Coke machines. At the end of the memo, John Bushey signed his name and then identified himself as 'the Coke dude'.

Bushey left Colorado Springs in 2000 and moved to Florida. He is now the principal of the high school in Celebration, a planned community run by The Celebration Company, a subsidiary of Disney.

Part IV

Localized Food Systems

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Coming in to the Foodshed

Jack Kloppenburg, Jr, John Hendrickson and G. W. Stevenson

For virtually everyone in the North and for many in the South, to eat is to participate in a truly global food system. In any supermarket here in Madison, Wisconsin, we can find tomatoes from Mexico, grapes from Chile, lettuce from California, apples from New Zealand. And, in what we take to be an indicator of a developing slippage between the terms 'sustainable' and 'organic', we can even buy organic blackberries from Guatemala (which may be organically produced, but in all likelihood are not sustainably produced if sustainable is understood to encompass more than on-farm production practices and any reasonable element of social justice). We cannot, however, count on finding Wisconsin-grown tomatoes, grapes, lettuce, strawberries or apples in any supermarket in Madison, even when those crops are in season locally.

That food in the US travels an average of 1300 miles and changes hands half a dozen times before it is consumed (*The Packer*, 1992) is deeply problematic. What is eaten by the great majority of North Americans comes from a global everywhere, yet from nowhere they know in particular. The distance from which their food comes represents their separation from the knowledge of how and by whom what they consume is produced, processed and transported. If the production, processing and transport of what they eat is destructive of the land and of human community – as it very often is – how can they understand the implications of their own participation in the global food system when those processes are located elsewhere and so are obscured from them? How can they act responsibly and effectively for change if they do not understand how the food system works and their own role within it?

Recognizing the ecological and social destructiveness of the globally based food system, a variety of analysts have suggested an alternative founded on respect for the integrity of specific socio-geographic places (Herrin and Gussow, 1989; Kneen, 1989; Berry, 1992; Crouch, 1993; Dahlberg, 1993; Friedmann, 1993; Gussow, 1993). Counterposed to the global food system in such analyses are self-reliant

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locally or regionally based food systems comprising diversified farms that use sustainable practices to supply fresher, more nutritious foodstuffs to small-scale processors and consumers to whom producers are linked by the bonds of community as well as economy. The landscape is understood as part of that community, and human activity is shaped to conform to knowledge and experience of what the natural characteristics of that place do or do not permit.

We find this vision of people living well and responsibly with one another and with the land on which they are placed to be deeply appealing. In our effort to work toward realization of that vision, we have found the notion of the foodshed to be particularly useful in helping us to analyse the existing food system, to imagine the shapes an alternative might take and to guide our actions. It is our purpose in this essay to elaborate and extend that concept and to share out initial understandings of its utility.

The term 'foodshed' was coined as early as 1929 (Hedden, 1929), but we were introduced to it by an encounter with the article 'Urban foodsheds', written by Arthur Getz (1991). The idea of a foodshed immediately triggered a wide range of unexpected insights and evocative associations. The intrinsic appeal the term had and continues to have for us derives in part from its relation to the rich and well-established concept of the watershed. How better to grasp the shape and the unity of something as complex as a food system than to graphically imagine the flow of food into a particular place? Moreover, the replacement of 'water' with 'food' does something very important: it connects the cultural ('food') to the natural ('shed'). The term 'foodshed' thus becomes a unifying and organizing metaphor for conceptual development that starts from a premise of the unity of place and people, of nature and society.

The most attractive attribute of the idea of the foodshed is that it provides a bridge from thinking to doing, from theory to action. Thinking in terms of foodsheds implies development of what we might call foodshed analysis, the posing of particular kinds of questions and the gathering of particular types of information or data. And foodshed analysis ought in turn to foster change. Not only can its results be used to educate, but we believe that the foodshed – no less than Gary Snyder's watershed – is a place for organizing. In this unstable postmodern world, the foodshed can be one vehicle through which we reassemble our fragmented identities, re-establish community and become native not only to a place but to each other.

In expanding on these points we will depart from Getz's usage in one significant way. Getz defines the foodshed as 'the area that is defined by a structure of supply' and notes that 'our most rudimentary map of a foodshed might cover the globe' (Getz, 1991, p26). We want to establish an analytic and normative distinction between the global food system that exists now and the multiplicity of local foodsheds that we hope will characterize the future. Since we give the term 'foodshed' this normative meaning, 'global foodshed' is for us an oxymoron. Within the existing food system there already exist alternative and oppositionalist elements that could be the building blocks for developing foodsheds: food policy councils, community-supported agriculture, farmers' markets, sustainable farmers, alternative consumers. We will use the term 'foodshed' to refer to the elements and properties of that preferred, emergent alternative.

A Foodshed in a Moral Economy

Where are we now? We are embedded in a global food system structured around a market economy that is geared to the proliferation of commodities and the destruction of the local. We are faced with transnational agribusinesses whose desire to extend and consolidate their global reach implies the homogenization of our food, our communities and our landscapes. We live in a world in which we are ever more distant from one another and from the land, so we are increasingly less responsible to one another and to the land. Where do we go from here? How can we come home again?

There can be no definitive blueprint for the construction of some preferred future Accordingly, we offer the foodshed not as a manifesto but as a conceptual vocabulary not as a doctrine but as a set of principles. Below we set out five principles that seem particularly important to us. We do not claim that these are either exhaustive or particularly original. We have drawn inspiration and insight from a wide variety of people whom we consider to be engaged – whether they know it or not – in foodshed work. We invite others to join in that work.

Moral Economy

A foodshed will be embedded in a moral economy that envelops and conditions market forces. The global food system operates according to allegedly 'natural' rules of efficiency, utility maximization, competitiveness and calculated self-interest. The historical extension of market relations has deeply eroded the obligations of mutuality, reciprocity and equity that ought to characterize all elements of human interaction. Food production today is organized largely with the objective of producing a profit rather than with the purpose of feeding people. But human society has been and should remain more than a marketplace. E. P. Thompson (1966, p203) describes a 'moral economy' as exchange 'justified in relation to social or moral sanctions, as opposed to the operation of free market forces'. Wendell Berry (1993, p14) points to similar ethical precepts when he writes of the need for 'social and ecological standards' to guide us toward the aims of human freedom, pleasure and longevity. The term 'moral economy' resonates for us and we use it here as a provisional shorthand phrase for the re-embedding of food production primarily within human needs rather than within the economist's narrow 'effective demand' (demand backed by ability to pay).

Adopting the perspective of the moral economy challenges us to view food as more than a commodity to be exchanged through a set of impersonal market relationships or a bundle of nutrients required to keep our bodies functioning. It permits us to see the centrality of food to human life as a powerful template around which to build non-market or extra-market relationships among persons, social groups and institutions who have been distanced from one another. The production and consumption of food could be the basis for the reinvigoration of familial, community and civic culture. We are all too well aware of the difficulty that will be involved in realizing this most fundamental principle of the foodshed. Nevertheless, we are encouraged by such innovations as community-supported agriculture (CSA) – 'partnerships of mutual commitment' between farmers and consumers (Van En and Roth, 1993). In CSA we have a concrete example of economic exchanges conditioned by pleasure, friendship, aesthetics, affection, loyalty, justice and reciprocity in addition to the factors of cost (not price) and quality.

The Commensal Community

CSA also serves as an illustration of our expectation that the moral economy of a foodshed will be shaped and expressed principally through communities. In *The Left Hand of Darkness* novelist, Ursula Le Guin (1969), imagines a society whose basic social unit is the Commensal Hearth. The word 'commensal' (from the Latin *mensa*, table) refers to those who eat together, and the word 'commensalism' is used in ecology to designate a relationship between two kinds of organisms in which one obtains food from the other without damaging it. We imagine foodsheds as commensal communities that encompass sustainable relationships both between people (those who eat together) and between people and the land (obtaining food without damage).

In human terms, building the commensal community means establishment or recovery of social linkages beyond atomistic market relations through the production, exchange, processing and consumption of food. Such social construction will occur among producers, between producers and consumers, and among consumers. Witness the recent proliferation of small-scale cooperative and collective production and marketing strategies implemented by farmers to meet growing consumer interest in organic, locally grown, non-industrial food. Other examples of such non-market cooperation from the upper Midwest include the mutual assistance commitments made within associations of small-scale producers of specialty cheeses, and the information and technology exchange that occurs through networks of farmers experimenting with the rotational grazing of dairy animals as an alternative to conventional, capital-intensive, confinement milk production systems (Hassanein and Kloppenburg, 1994). With respect to new relationships between producers and consumers, emerging cooperative linkages between fresh vegetable growers and neighbourhood restaurants and consumer coops parallel the birth of CSA and the revitalization of farmers' markets (Waters, 1990; Hendrickson, 1994). Among consumers themselves, buying clubs, community gardens and changing patterns of food purchase reflect growing concern with the social, economic, ethical, environmental, health and cultural implications of how they eat.

While concrete precursors of what could conceivably become commensal communities are now visible, commitment to a moral economy requires that we work to make those communities as inclusive as possible. The sustainable agriculture movement has so far tended to be 'farm-centric' (Allen and Sach, 1991, p587) 'and has not yet seriously engaged issues of race, class, and gender even within – much less outside – rural areas'. Hunger in the city is indeed an agricultural issue (Ashman et al, 1993; Clancy, 1993). The commensal community should confront and address the need not just for equitable access to food but also for broader participation in decision making by marginalized or disempowered groups. That progress is possible is evidenced by the activities of the Hartford Food System, which has made a priority of linking farmers directly to low-income consumers (Winne, 1994) and by initiatives to foster the acceptance of food stamps at farmers' markets. The 'food policy councils' now being created in a variety of US and Canadian cities are indicators of the plausibility of addressing foodshed issues by relating food affairs to other fundamental community dimensions such as economic development and nutrition and public health (Dahlberg, 1993; Toronto Food Policy Council, 1993).

Finally, the standards of a commensal community require respect and affection for the land and for other species. It is through food that humanity's most intimate and essential connections to the Earth and to other creatures are expressed and consummated. In the commensal community, production, processing, distribution, consumption and waste disposal will be organized so as to protect and, where necessary, to regenerate the natural resource base. Responsible stewardship will involve sustainable cropping and humane livestock practices, reduced use of non-renewable energy sources and a commitment to recycling and reuse.

Self-protection, Secession and Succession

The dominant dynamics of the global food system actively erode both moral economy and community. We agree with those who believe that this destructiveness is an inherent property of that system and that what is needed is fundamental transformation rather than simple reform (Allen and Sachs, 1991; Orr, 1992; Berry, 1993; Friedmann, 1993). Still, given the current dominance of the existing world food economy, people working toward foodshed objectives will need to carve out insulated spaces in which to maintain or create alternatives that will eventually bring substantive change. In opposition to the extension of the market system, there have always been examples of what Friedmann (1993, p218) calls 'movement(s) of self-protection'. From the Luddites of 19th century Britain to the Zapatistas of contemporary Chiapas, we have seen continuous refusal to submit without contest to the dictates of the globalizing food system. At the margins of consumer society and in the interstices between McDonald's and Monsanto and Philip Morris are all manner of alternative producers and eaters – Amish, vegetarians, rotational graziers, seed savers, food coop members, perennial polyculturists, bioregionalists, home gardeners, biodynamicists – who are producing and reproducing a rich set of alternative agrofood possibilities.

What these diverse people and groups share is that their activities and commitments involve various degrees of disengagement from the existing food system and especially from the narrow commodity and market relations on which it is based. We follow Berry (1993, pp17–18) and Orr (1992, p73) in our conviction that a fundamental principle of the foodshed is the need for 'secession'. This principle is based on a strategic preference for withdrawing from and/or creating alternatives to the dominant system rather than challenging it directly. Certainly, in many circumstances direct opposition to elements of the global food economy is appropriate and necessary (the situation in Chiapas, or the current manipulation of the Green Bay Cheese Exchange by food corporations such as Kraft and Pizza Hut). A primary strategy of the secession principle is 'slowly hollowing out' (Orr, 1992, p73) the structures of the global food system by reorganizing our own social and productive capacities. This is essentially what grazier groups are engaged in as they rediscover their own, indigenous capacity for producing the knowledge they need to be 'grass farmers', and as they withdraw from the agribusiness firms and agricultural scientists who have been doing their thinking for them (Hassanein and Kloppenburg, 1994).

A second and corollary point is that of 'succession', or the conscious and incremental transfer of resources and human commitments from old food-associated relationships and forms to new ones. Neither people nor institutions are generally willing or prepared to embrace radical change. The succession principle finds expression in a strategy of 'slowly moving over' from the food system to the foodshed. Food presents people with hundreds of small opportunities to take increasingly important steps away from the global market economy and toward the moral economy. An example is the consumer who decides not to purchase milk produced using recombinant bovine growth hormone (rBGH). While the motivation for that initial, simple step may be narrowly based on personal health considerations, the potential is there for making further connections. Once the link between rBGH and Monsanto is made, the consumer may become aware of the corporate/chemical/food link more generally and begin moving a progressively higher percentage of the household food budget into purchases from alternative food sources. Similarly, restaurants or schools may be encouraged to purchase more of their food supplies from local producer cooperatives as these foodshed alternatives generate capacity.

Proximity (Locality and Regionality)

We see certain key spatial components to the secession and succession dynamics as characterizing the foodshed. If mitigation of the deleterious effects of distancing is the central challenge posed by the operation of the global food system, then greater attention to proximity – to that which is relatively near – should be an appropriate response. But apart from the principle of relative proximity, it is not clear precisely where the revised boundaries ought to be drawn. The limits of a foodshed will be a function of the shapes of multiple sets of boundaries; that is, of the aggregated boundaries of the climatic features, plant communities, soil types, ethnicities, cultural traditions, culinary patterns and the like, of which foodsheds are composed. Hence we identify proximity rather than locality or regionality per se as a fundamental principle of the foodshed. Though their precise boundaries will rarely be sharply defined, we insist that foodsheds are socially, economically, ethically and physically embedded in particular places.

We do not, however, imagine foodsheds as isolated, parochial entities. While they might be – in Marge Piercy's (1976) term – as 'ownfed' as possible, we see them as self-reliant rather than self-sufficient. Self-reliance implies the reduction of dependence on other places but does not deny the desirability or necessity of external trade relationships (Friedmann, 1993, p228; Gussow, 1993, p14). For too long, however, trade in the global food economy has meant farmers selling low-value commodities to distant markets and processors and the subsequent reimportation of finished food products at high prices. In the foodshed, efforts would be made to increase the level of local and intra-regional food production, processing and distribution and so to retain economic value and jobs. Since economic concentration is a prime engine of distancing, secessionist and successionist alternatives ought to be built around small and mid-sized enterprises (dairies, cheese factories, smithies, greenhouses, canneries, restaurants, specialty markets) capable of responding affirmatively to the opportunities and responsibilities of the emergent commensal community.

The self-reliance associated with proximity is closely linked to both social and environmental sustainability. A community that depends on its human neighbours, neighbouring lands and native species to supply the majority of its needs must ensure that the social and natural resources it utilizes to fulfil those needs remain healthy. A consequence of proximate self-reliance is that social welfare, soil and water conservation, and energy efficiency become issues of immediate practical concern. For example, it is difficult for most city dwellers to be concerned about preserving farmland unless the destruction of farmland directly affects their food supply, or unless they know and care for the paving over of the land. Awareness of and affection for one's place can forestall the ethical distancing so characteristic of the global food system. In the foodshed, collective responsibility for stewardship of people and of the land becomes a necessity rather than an optional virtue.

Nature as Measure

We understand the foodshed to be a socio-geographic space – human activity embedded in the natural integument of a particular place. That human activity is necessarily constrained in various ways by the characteristics of the place in question.

Ignoring those natural constraints or overriding them with technology is one of the besetting sins of the global food system, the ecological destructiveness of which is now unambiguously apparent even to its apologists. In the foodshed, natural conditions would be taken not as an obstacle to be overcome but as a measure of limits to be respected.

While restraints on human activity will indeed often be required, to interpret natural parameters in terms of 'deficiency' rather than 'capacity' is to fail to transcend the conventional industrial mindset. Nature may be understood not just as a set of limits but as an exemplar of the possible, as an almanac of potential models for human conduct and action (Jackson, 1980; Orr, 1992, p33; Quinn, 1993). For example, from the perspective of the foodshed, one answer to Berry's (1987, p146) query, 'What will nature help us do here?' points toward the development of regional palates based on 'moving diets' of locally and seasonally available food. Who knows what lessons nature may offer us should we free ourselves to see its 'capacity'? These opportunities are by no means obvious. They must be discovered in intimate, extended conversation with the land. By acting with respect and affection for the natural world, we may begin to produce and eat *in* harmony with and within the rhythms and patterns of the places in which we live.

Ironically, much foodshed analysis will necessarily involve examination and explication of the structure and dynamics of the existing global food system. That food system exists and is a powerful and dominating structure indeed. Secession – even for so solitary a group as the Amish – can now be only partial and contingent. Emergent elements of what might become foodsheds are presently embedded in and often constrained by the rules, interests and operations of regional and global actors and institutions.

Aldo Leopold (1970, p137) suggested that we need to learn to 'think like a mountain'; that is, to think ecologically, to engage the hidden and unlooked-for connections among the elements of a system or between different levels of a system. Until and unless we know where we are in the larger social and political ecology of the global food system, we may not be able to move effectively toward realization of a foodshed locally. We do not necessarily have to accept the demands of the global food system, but we must understand and realistically address the constraints it imposes if we are to identify the space it permits for secessionist activities or simple self-protection.

Foodshed analysis will not eschew engagement with issues at the national or even the global level. It will ask that this extra-local investigation serve the objective of framing the prospects for successfully implementing concrete initiatives or changes within a particular socio-geographic place. Foodshed analysis will involve investigation of the existing food system in order to inform strategic decisions regarding opportunities for self-protection and secession. Such analysis should include the identification, celebration and study of existing and emergent alternatives to the food system. Ultimately foodshed work should seek to link such elements in a system of mutual support and integration, with the objective of fostering emergence of a truly alternative system: the foodshed. While as a general rule it is advisable to think and act as proximately as we can, we must recognize that the appropriate and necessary locus of both thought and action in the foodshed may sometimes be regional, national or even global.

Concretely, what would foodshed analysis entail? In simplest terms, it means answering Getz's basic question, 'Where is our food coming from and how is it getting to us?' For us, a substantial part of the appeal of the term 'foodshed' has to do with the graphic imagery it evokes: streams of foodstuffs running into a particular locality, their flow mediated by the features of both natural and social geography. Measuring the flow and direction of these tributaries and documenting the many quantitative and qualitative transformations that food undergoes as it moves through time and space toward consumption is the central methodological task of foodshed analysis.

What unit of analysis is appropriate for such study; what, after all, are the boundaries of a foodshed? What kinds of data or information ought to be collected? Answers to these questions will vary as a function of who is engaging in the analysis and what their objectives and resources are. The foodshed is not a determinate thing; foodshed analysis will be similarly variable. It may involve collection of data on local exports of corn or the capacity of the local landfill, on the distribution of edible plant species or the patterns of human hunger, on the organization of harvest festivals or the composition of the county board, on the content of school lunch menus or the forage preferences of diary cows.

Foodshed analysis will not be constructed to conform to some predetermined theoretical and methodological framework, but will be constituted by the concrete activities of those who seek to learn about the food system in order to change it. Many such projects have been completed or are under way at a variety of levels. The Cornucopia Project, organized by Rodale Press in Pennsylvania in the 1980s, chose states as its unit of analysis and emphasized collection of aggregate state-level data suited to the project's objective of raising the general public's awareness of the vulnerabilities of the national food system through state-specific reports and publicity (Rodale, 1982; Rural Wisconsin Cornucopia Task Force, 1982). Also at the state level, several studies by nutritionists have been undertaken in order to explore the parameters and implications for human health of sustainable, regional diets (Herrin and Gussow, 1989; Hamm, 1993).

Using cities as their socio-geographic framework, a variety of 'food policy councils' have been created to address issues of sustainability and equity in the food system (Hartford Food System, 1991; Dahlberg, 1993; Toronto Food Policy Council, 1993). The students and staff at several colleges have taken their own institutions as the basic unit of analysis and explored the rationale and mechanisms for getting commitments from their colleges to buy local food (Bakko and Woodwell, 1992; Valen, 1992). Local food projects at Hendrix College in Arkansas and Saint Olaf and Carleton colleges in Minnesota were successful in reorienting food purchasing patterns to more proximate sources. The degree of resolution characteristic of the lens of foodshed analysis can become very fine grained indeed. One of the most impressive and revealing analyses we have encountered is a self-study of a personal foodshed – 'from gut to ground' (Peterson, 1994) – that explores individual consumption and its implications for personal responsibility in the global food system.

An example of foodshed analysis that focuses on the urban poor is an initiative undertaken under the auspices of the Southern California Interfaith Hunger Coalition (IHC). The IHC's report, *Seeds of Change: Strategies for Food Security for the Inner City*, is an ambitious and finely realized effort to take an 'integrated, whole-systems approach' to assessing the need and prospects for reforming the existing food system in a specific and delimited place (Ashman et al, 1993). The IHC document is also of interest because the research and analysis for the report was undertaken largely by students and faculty from the University of California at Los Angeles. Much criticism has been directed toward universities (especially toward the land-grant colleges) for their subservience to industrial interests and their failure to orient knowledge production to local or regional needs.

Seeds of Change is striking evidence that academics can work effectively with advocacy groups oriented to transformation of the food system.

Although few of those whose efforts we have described think of what they do as 'foodshed analysis', we feel they are moving in directions similar to ours. To the extent that these diverse projects and undertakings are complementary, they constitute a rich set of conceptual and methodological resources for thinking about and assessing the nature and structure of the global food system in which we are now embedded, and for helping us to consider how and where we can realistically expect to make changes.

Radical Reformism

It is apparent to increasing numbers of people that fundamental changes are needed in the global food system. Of course, we see that the question of food is simply a specific case of the general failure of late capitalism, or post-industrialism or post-modernism or whatever you wish to call this period of intense commodification and of accelerating distancing from one another and from the Earth. We could equally well be calling for fundamental changes in the global health system, the global industrial system, the global political system, the global monetary system or the global labour system. Ultimately, what sustainability requires of us is change in global society as a whole. We need the recovery and reconstitution of community generally, not simply in relation to food. Although we may strive to think like mountains, we must act as human beings. To start the global task to which we are called, we need a specific place to begin, a specific place to stand, a specific place to initiate the small, reformist changes that we can only hope may some day become radically transformative.

We start with food. Given the centrality of food in our lives and its capacity to connect us materially and spiritually to one another and to the Earth, we believe that it is an appropriate place to begin. We offer the term 'foodshed' to encompass the physical, biological, social and intellectual components of the multidimensional space in which we live and eat. We understand the foodshed as a framework for both thought and action. If our use of the term has any virtue, perhaps it is to help people see the relatedness of apparently disparate elements, and to perceive the complementarity of different but parallel initiatives for change. We also think it useful to make a semantic distinction between where we are now and where we wish to be in the future. Thinking and acting in terms of the foodshed is an indication of our commitment to work not simply to reform the food system but to transcend that system entirely. And while a system can be anywhere, the foodshed is a continuous reminder that we are standing in a specific place; not anywhere, but here.

We need to keep place firmly in our minds and beneath our feet as we talk and walk our way toward a transformed future. Because the path is long and because we must build it as we go – the foodshed offers a project, not a blueprint – our actions will be 'slow small adjustments in response to questions asked by a particular place' (Berry, 1990, p121). We share Orr's (1992, p1) hope for 'a rejuvenation of civic culture and the rise of an ecologically literate and ecologically competent citizenry who understand global issues, but who also know how to live well in their places'. If we are to become native to our places, the foodshed is one way of envisioning that beloved country.

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17

Farm Costs and Food Miles: An Assessment of the Full Cost of the UK Weekly Food Basket

J. Pretty, A. S. Ball, T. Lang and J. I. L. Morison

Evaluating Farm and Food Systems in Industrialized Countries

Recent years have seen growing concern about the sustainability of agricultural and food systems and the unintended side effects that can be imposed on environment and human health (Conway and Pretty, 1991; Pretty, 1995, 2002; NRC, 2000; Uphoff, 2002; Lang and Heasman, 2004). There are many perspectives on what constitutes sustainability and how it can be applied equally across agricultural contexts (Naess, 1992; Dobson, 1999; Pretty et al, 2003a). As a result, a variety of analytical approaches have been developed, including energy accounting (Leach, 1976; Cormack and Metcalfe, 2000; Carlsson-Kanyama et al, 2003), economic valuation of non-marketed goods and services (Pearce and Turner, 1990; Daily, 1997; Costanza et al, 1997; Pretty et al, 2000, 2001), ecological footprints (Rees, 2003), carbon accounting (Smith and Smith, 2000; Lal et al, 2004) and the use of indicators for sustainability (Lewis et al, 1997; Bailey et al, 1999; OECD, 1998; MAFF, 2000; Caporali et al, 2003).

Most of these approaches have focused on environmental impacts up to the farm gate and have not assessed the additional environmental effects of transporting foodstuffs via processing to retail outlets and then to the point of consumption. Evidence is mounting that these farm to plate transport costs, or 'food miles' (Raven and Lang, 1995; Subak, 1999; Jones, 2001; Pirog et al, 2001; Garnett, 2003; Stephens et al, 2003), could be substantial. In addition, there is growing interest in local and regionalized food supply systems and the potential social and environmental benefits they could bring (Marsden et al, 2000; Cowell and Parkinson, 2003; Morris and Buller, 2003; Sage, 2003; Winter, 2003).

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In this study, we assess the full cost of the UK weekly food basket by analysing the environmental costs to the farm gate for each major food commodity and the additional environmental costs of transporting foods to retail outlets and then to consumers' homes, and the cost of disposal of wastes. We then develop various production and transport scenarios to assess the best cost-avoidance options, and indicate where policy priorities should lie in the light of the findings.

The externalities arising from farm and food systems point to some important policy priorities for industrialized countries in Europe, North America and the OECD, where there are many similarities in both farm technologies and distribution systems for food. Important drivers that may differ from country to country include the quality and types of food eaten (as costs vary greatly according to commodity), the amount of farm inputs used that result in external costs, the average distance travelled by food from farm to plate and the proportion of foods imported that impose externalities in other countries, thereby effectively exporting costs (Lang and Heasman, 2004). Some of these costs could be avoided with the adoption of more sustainable farming and food distribution systems.

The external benefits of agricultural systems include a wide range of unpriced goods and services, such as recreation and amenity value of landscapes, water holding capacity, carbon sequestration, wildlife and biodiversity and contributions to rural economies and communities (Bollman and Bryden, 1997; Pretty, 2002, 2004; Renwick et al, 2002; Dobbs, 2004). We do not address here the contributions that agricultural and land use systems make to positive externalities and so do not seek to make any cost–benefit comparisons. There is a danger that this will appear to bias our analysis against modern agriculture. These positive side effects are known to be substantial: for example, some 550 million day-visits are made to the countryside each year by urban people who derive value and pleasure from the farmed landscape. However, no study has yet put an aggregate value on the positive externalities. In this study, we therefore do not make any judgement about the comparative differences in contribution that conventional and organic farms make to positive externalities.

Environmental Costs to the Farm Gate

The environmental costs of farming have been recently assessed for the UK (Pretty et al, 2000, 2001; Hartridge and Pearce, 2001; EA, 2002), Germany (Waibel et al, 1999) and the US (Subak, 1999; Tegtmeier and Duffy, 2004). For this study, earlier data on UK farm externalities (Pretty et al, 2000, 2001; Hartridge and Pearce, 2001; EA, 2002) were reassessed by incorporating new data on eutrophication, greenhouse gas costs, energy embodied in inputs and BSE (Renwick et al, 2002; Pretty et al, 2003b; Defra, 2004). The methods used in these studies are largely cost-based rather than demand-based and involve the use of replacement costs (e.g. hedgerows, wetlands), substitute goods (e.g. bottled water), loss of earnings (e.g. due to ill-health) and clean-up costs (e.g. removal of pesticides and nitrate from drinking water). Demand-based methods using willingness to pay (or be compensated) have tended to be used in studies to put a value on landscapes (Hanley et al, 1998).

One problem with all such studies is the difficulty of baselines and absolute costs. For example, if there were no livestock, then methane costs would be very much reduced. But if there were no agriculture, then there would still be an amenity value arising from the landscape. Thus these costs of agriculture are relative to an artificial baseline of zero. For our purposes here, the comparison between different agricultural systems (conventional and organic) provides an escape from this artificiality.

The UK studies indicate that total agricultural environmental and health costs are some £1514 million (M) for the year 2000 (35 per cent lower than originally calculated in Pretty et al, 2000). Some costs remain impossible to assess, such as antibiotic resistance arising from prophylactic use in livestock systems and the chronic health effects of pesticides, and these are not included.

In Table 17.1, we compare the external costs of the current agricultural system with those that would arise were the whole of the UK farmed with organic production systems. The choice of this scenario is not because organic is the only form of agricultural system that is more sustainable than current practices, but because it has a well-defined system of standards (EC Regulation 2092/91; FAO/WHO,

Table 17.1 *The negative externalities of UK agriculture (year 2000)*

Source of adverse effects	*Actual costs from current agriculture (£M yr^{-1})*	*Scenario: costs as if whole of UK was organic (£M yr^{-1})*
Pesticides in water	143.2	0.0
Nitrate, phosphate, soil and *Cryptosporidium* in water	112.1	53.7
Eutrophication of surface water	79.1	19.8
Monitoring of water systems and advice	13.1	13.1
Methane, nitrous oxide, ammonia emissions to atmosphere	421.1	172.7
Direct and indirect carbon dioxide emissions to atmosphere	102.7	32.0
Off-site soils erosion and organic matter losses from soils	59.0	24.0
Losses of biodiversity and landscape values	150.3	19.3
Adverse effects to human health from pesticides	1.2	0.0
Adverse effects to human health from micro-organisms and BSE	432.6	50.4
Totals	£1514.4	£384.9

Sources: Adapted from Pretty et al, 2000; Hartridge and Pearce, 2001; EA, 2002

2001; IFOAM, 2000). Organic agriculture is a defined and certified system of agricultural production that seeks to promote and enhance ecosystem health whilst minimizing adverse effects on natural resources. It is seen not just as a modification of existing conventional practices, but as a restructuring of whole farm systems (Lampkin and Padel, 1994; FiBL, 2000; Scialabba and Hattam, 2002; Caporali et al, 2003; Reganold, 2004). In 2003, there were 4104 organic farms in the UK covering some 741,000ha (Defra, 2003). We used standard organic protocols to estimate the contribution that would be made to total costs by each of the ten sectors listed in Table 17.1. Pesticide costs arising from drinking water contamination and adverse effects on human health are assumed to fall to zero under an organic farming regime, as are any costs associated with BSE. Most of the other sectors would see declines in costs compared with conventional farming, but not to zero. Our assumptions on these are as follows:

1 for drinking water, nitrate costs are assumed to fall by 20 per cent, phosphate and soil losses by 75 per cent, zoonoses by 20 per cent, eutrophication by 75 per cent, with monitoring costs remaining the same;
2 for gaseous emissions, methane costs from livestock are assumed to fall by 5 per cent, ammonia by 25 per cent, nitrous oxide by 80 per cent, carbon dioxide from fuel use remains the same and indirect emissions through reduced use of fertilizers and pesticides by 88 per cent;
3 for soil costs, off-site damage is assumed to fall by 20 per cent and carbon dioxide losses in organic matter by 75 per cent;
4 for biodiversity and landscape losses, costs are assumed to fall by 75 per cent for wildlife and by 90 per cent for hedgerows losses, though remain the same for bee colonies;
5 for micro-organisms and disease-agents, costs are assumed to fall by 75 per cent.

We estimated that a complete switch to organic agriculture could lead to cost-avoidance (i.e. benefits compared with current agricultural systems) of £1129M yr^{-1}.

These aggregate costs were used to calculate the costs for each of the 12 major arable, horticulture and livestock food commodities produced in the UK (cereals, potatoes, oil seed rape, sugar beet, fruit, vegetables, beef/veal, pork, poultry, mutton/lamb, milk and eggs). We assessed 19 categories of environmental costs for each of these 12 commodities and calculated the relative contribution of each commodity to each cost category. In some cases, there is only one source for a problem (e.g. BSE from cattle); in others, there are multiple sources (e.g. nitrate from crops and livestock systems). We used various Defra data sets on area devoted to each commodity, on animal numbers, on input-use and on emissions to calculate these proportional contributions from each commodity (mean values taken for 1999–2001). In the UK, there are 4.89M ha of arable and 6.67M ha of grassland (not including rough and hill grazing).

The basis for the allocations of each of the categories of negative externalities to the 12 crop and livestock commodities were as follows (see Pretty et al, 2000, 2001 for full details and references for each category):

1 Of all pesticide costs, 80 per cent were allocated in proportion to area of each arable crop and the remaining 20 per cent evenly spread across all livestock categories.
2 Nitrate costs were allocated in proportion to area of each crop commodity and grassland for livestock.
3 Phosphate and soil erosion costs were allocated mainly to arable crops (91 per cent), with an allocation to pigs for leaching (9 per cent).
4 One third of *Cryptosporidium* costs were allocated to each of milk, beef and sheep, as the pathogen does not occur in pigs or poultry.
5 Eutrophication costs were allocated in proportion to area of crops and grassland.
6 Monitoring costs were allocated in proportion to area of all crops and grass.
7 Some 89 per cent of agricultural methane emissions arise from enteric animals (75 per cent from cattle, 25 per cent from sheep), while the remaining 11 per cent arises from manures of all animals (costs are equally allocated); and thus milk is calculated to contribute 35 per cent to methane costs, beef/veal 35 per cent, mutton/lamb 25 per cent, and pork and poultry 2.5 per cent each.
8 Ammonia costs arising from livestock wastes were allocated 20 per cent each to milk, beef, pork, poultry and sheep.
9 Nitrous oxide costs were allocated in proportion to area of crops and grassland.
10 Carbon emitted from fossil fuel use (mostly for vehicles) was in proportion to area of crops and grassland, with costs adjusted up (double their proportional contribution) for pigs, poultry and eggs (owing to energy used in housing) and down by half for sheep (which are mostly outdoors).
11 Indirect energy costs arising from the manufacture of pesticides and fertilizers were allocated in proportion to the areas of crops and grassland.
12 Off-site soil erosion costs were allocated in proportion to the areas of crops and grass.
13 Organic matter carbon losses were allocated in proportion to just arable area (it is assumed that losses from grassland are negligible).
14 Biodiversity and wildlife costs were allocated in proportion to the area of crops and grassland.
15 Costs arising from losses of landscape features were allocated in proportion to area, with greater losses of hedgerows assumed to occur in arable rather than under beef/sheep.
16 Bee colony losses were proportional to just arable area.
17 The costs arising from acute pesticide adverse effects were allocated to 50 per cent for sheep dips, 40 per cent for cereals and the remainder spread amongst remaining crops.

18 Some 75 per cent of the costs to consumers from outbreaks are assumed to arise after the farm gate, and of the remaining quarter pathogenic outbreaks in food, some 90 per cent are from livestock produce and 5 per cent each from fruit and vegetables.
19 BSE and new variant CJD costs were allocated to cattle alone.

The total costs arising from the cultivation and raising of each of the 12 commodities are shown in Table 17.2, together with the unit costs per kg, litre or dozen eggs using average UK production data for 1998–2001 (Table 17.2). The same series of calculations are shown for an organic production scenario. On a per kg basis, livestock produce imposes the greatest costs: beef/veal 64.8p kg^{-1}, mutton/lamb 43.6p kg^{-1}, pork 12.8p kg^{-1}, poultry 5.68p kg^{-1}. Oil seed rape imposes the highest costs for arable and horticultural produce (3.45p kg^{-1}), followed by cereals (1.72p kg^{-1}), fruit (1.44p kg^{-1}), vegetables (0.61p kg^{-1}), potatoes (0.42p kg^{-1}) and sugar beet (0.22p kg^{-1}). Some of these external costs are a significant proportion of the price received for commodities. For example, the 1.72p kg^{-1} external cost for cereals represents a value of 17.7 per cent of the average UK price of wheat in the first half of 2004; the 3.96p dozen $eggs^{-1}$ is 6.3 per cent of average

Table 17.2 *External costs to the farm gate for 12 food commodities grown and raised in the UK*

Produce	*External costs from conventional agriculture*		*Scenario: as if whole of UK was organic*		*Proportional change in external costs from conventional to organic (%)*
	Total external cost (£ M yr^{-1})	*Unit external costs (p kg^{-1})*	*Total external cost (£ M yr^{-1})*	*Unit external cost (p kg^{-1})*	
Cereals	377.5	1.72	71.1	0.32	–18.6
Potato	28.2	0.42	3.5	0.05	–11.9
Oil seed rape	49.9	3.54	9.7	0.69	–19.5
Sugar beet	20.6	0.22	3.7	0.04	–18.2
Fruit	4.6	1.44	0.8	0.25	–17.4
Vegetables	17.6	0.61	3.0	0.10	–16.4
Beef/veal	441.9	64.79	82.5	12.09	–18.7
Pork	127.3	12.81	37.6	3.79	–29.6
Poultry	87.5	5.68	29.4	1.91	–33.6
Mutton/lamb	157.8	43.57	59.0	16.30	–37.6
		(p $litre^{-1}$)		**(p $litre^{-1}$)**	
Milk	171.2	1.22	73.3	0.52	–42.6
		(p dozen $eggs^{-1}$)		**(p dozen $eggs^{-1}$)**	
Eggs	30.3	3.96	11.3	1.44	–36.4

2003–2004 UK price; and the 0.42p kg^{-1} external cost for potatoes is 3.0 per cent of the average 2003–2004 UK price (Defra, 2004).

With these unit costs for food commodities, it is now possible to reassess the full costs of each of the components of the weekly UK food basket.

The Weekly Food Basket

The National Food Survey (NFS) and the Food Expenditure Survey (FES) (combined in 2003 as the Expenditure Food Survey) record data on weekly consumption and expenditure for each item of food in the average domestic food basket (Defra, 2002a, 2002b). On average, each person in the UK consumes in the home 10.02kg of food wk^{-1} and this costs £17.26 wk^{-1} (average for 1999–2000). In addition, individuals spend £7.53 wk^{-1} on eating out (an average of three times per week), bringing the total weekly expenditure to £24.79 (eating out is 30 per cent of food expenditure) for 11.68kg of food (see Table 17.3).

These data are obviously aggregate commodity costs for the whole of the UK and its food system. There will, however, be geographic and income-group variations according to choice of food consumed and expenditure. The average weekly food basket in Scotland is 4.4 per cent less than the UK average, 6.8 per cent less in Wales, 1.2 per cent less in Northern Ireland and 0.8 per cent more in England. The most expensive two regions of England are London at £19.53 (+10.7 per cent) and the South East at £20.35 (15.4 per cent), and the least expensive are Yorkshire and Humberside at £16.08 (–9.1 per cent) and the North East at £16.13 (–8.6 per cent). Households earning >£725 gross wk^{-1} spend £22.03 (+24.9 per cent), while those earning £180–375 spend 10.6 per cent less and those on <£180 spend 20.3 per cent less (Defra, 2002a, 2002b).

In order to relate external commodity costs (in pence kg^{-1}, p l^{-1} and p dozen $eggs^{-1}$ produced) to the environmental costs arising from the food choices made by consumers, several adjustments were made to account for losses in the supply chain and distortions arising from imbalances in imports and exports. A loss factor for each food product was calculated, as some produce is fed to animals (e.g. 73 per cent of all cereals are fed to livestock: 1.49Mt to cattle, 0.45Mt to pigs, 0.13Mt to poultry, 0.097Mt to sheep, for a total of 2.16Mt in 1999–2000), some is lost as waste, some is converted into secondary products or prepared meals (e.g. wheat to flour to bread, barley to beer) and some is disposed to landfill. Using the two national food surveys, weekly consumption data for the UK population of 59.64 M people were compared with national domestic agricultural production data to calculate a loss factor for each commodity.

In addition, further adjustments for imports and exports of foods have been made. Some of the farm externalities incurred in the UK are for food produced in the UK that is then exported and some of the food consumed is from imported produce where farm externalities are incurred in overseas agricultural systems.

Table 17.3 *Components of UK weekly food basket and expenditure per person, plus price of each component including externalities to farm gate*

Components of food basket	*Consumption (home + eating out) g person^{-1} wk^{-1}*	*Expenditure (p person^{-1} wk^{-1})*	*Price including externalities from current agriculture (p person^{-1} wk^{-1})*	*Price including externalities if all organic agriculture (p person^{-1} wk^{-1})*[1]
Liquid milk	751	37.6	39.4	38.4
Other milk and cream	1401	103.7	107.2	105.2
Cheese	135	72.4	91.3	75.9
Fats/oils	196	37.9	39.3	38.2
Eggs (no.)	1.72	17.3	18.4	17.7
Beef/veal	142	72.9	93.0	76.7
Lamb/mutton	68	33.1	39.5	35.5
Pork	83	32.2	33.1	32.5
Poultry	262	91.3	94.6	92.4
Bacon/other meat	487	222.5	227.7	224.1
Fish	166	97.3	97.3[2]	97.3[2]
Fresh potatoes	797	39.5	40.7	39.7
Fresh green vegetables	273	40.2	40.4	40.3
Other green vegetables	526	69.8	70.1	69.9
Processed vegetables	578	107.3	107.7	107.4
Fresh fruit	738	96.0	96.9	96.1
Other fruit and fruit products	373	42.7	43.2	42.8
Sugar and preserves	139	14.3	14.4	14.3
Bread	804	83.9	87.8	84.6
Cakes and biscuits	285	84.2	85.5	84.4

Table 17.3 *(continued)*

Components of food basket	*Consumption (home + eating out) g person^{-1} wk^{-1}*	*Expenditure (p person^{-1} wk^{-1})*	*Price including externalities from current agriculture (p person^{-1} wk^{-1})*	*Price including externalities if all organic agriculture (p person^{-1} wk^{-1})[1]*
Other cereals and cereal products	544	140.4	143.1	140.9
Beverages (tea, coffee)	405	401.9	401.9[3]	401.9[3]
Other foods	387	77.1	79.0	77.4
Ice cream & products	139	25.6	26.0	25.8
Soft drinks (ml)	1129	74.2	74.9	74.4
Alcoholic drinks (ml)	806	322.6	326.5	323.3
Confectionary	72	41.5	41.6	41.5
TOTAL[4]	11.68kg	£24.79	£25.60	£24.98
Increase in price over actual paid			+3.27%	+0.77%

Notes:

1 Organic scenario does not include price premiums
2 Fish: no data on externalities costs from capture fisheries or aquaculture
3 No costs allocated for tea/coffee as grown overseas
4 Totals may not sum due to rounding.

Here we make an adjustment to account for externalities only incurred in the UK to reflect environmental costs imposed by the current agricultural and food system and its mixture of exports and imports. It is important to note, however, that individual countries could reduce the negative environmental impacts of their agricultural systems by ceasing domestic production and switching to importing food. This would not lead to net environmental benefits at the global scale if this simply displaced externalities. Alternatively, if the overseas production systems were more environmentally beneficial in comparison with domestic ones, then there may be a net environmental benefit (after transport costs were also accounted for). Here we simply take account of the current export–import patterns to reflect where domestic costs are imposed.

Using Defra data (mean 1999–2000) on imports and exports of the 12 commodities, ratios for domestic produce as a proportion of total consumption were calculated for each commodity. Only two have a ratio of <1, indicating that they are net exported (cereals 0.91, oil seed rape 0.82), the remainder varying from 1.04 for sheep products (where imports and exports are almost balanced) to 9.62 for fruit (where imports greatly exceed exports). Total annual food commodity movements are 19.6Mt, comprising 12.2Mt yr^{-1} for imports and 7.4Mt yr^{-1} for exports, of which swapped commodities (with technically the same produce both imported and exported) amount to 5.23 Mt yr^{-1}. For example, 0.48Mt of pork is imported each year, while 0.21Mt is exported; 0.41Mt of milk is imported and 0.43Mt exported; and 0.13 M sheep are exported while 0.12 M are imported. Not all this produce is entirely substitutable, as imports and exports may be of different meat cuts or different types of animal. However, it is likely that commodity transport movements could be reduced.

After adjustments for losses in the food chain and for imports–exports, costs for p kg^{-1} consumed rather than p kg^{-1} produced were calculated. These were applied to each item of food consumed in the weekly food basket, giving a total of 81.2p wk^{-1}, or an additional 3.27 per cent on the price of the weekly food basket, raising the real cost including environmental externalities to the farm gate to £25.60 (Table 17.3). In the food basket, no externalities for fish consumption were calculated, as there were no appropriate data, and none were added for overseas produce (e.g. coffee, tea) where farm externalities have not occurred in the UK. However, if this 81.2p were multiplied by the total UK population, then it would wrongly imply costs greater than the £1514 M yr^{-1} calculated for farm externalities. This is because imports to the UK are greater than exports and so externalities arising from total consumption are greater than from production alone.

The costs for a wholly organic food basket scenario were also calculated (Table 17.3). We assume that this organic food basket has the same constituents as the average UK food basket and that prices do not affect these proportions. These costs amount to an additional 19.45p in environmental costs to the farm gate, or equivalent to an extra 0.79 per cent on the price paid for the food basket. But consumers already pay a premium on organic food at most retail outlets, so their food basket already costs more than conventional food. Retail price data on each food product (Hamm et al, 2002; Ross, 2002) were used to calculate the cost of an identical but organically sourced food basket. Two sources were compared: (i) supermarkets, where the average premium is 53 per cent; and (ii) local box schemes and farm shops, where the average premium is 31 per cent. The weekly food basket would cost £39.37 if bought at a supermarket (59 per cent more than conventional) and £33.39 if bought via the local scheme (35 per cent more than conventional).

Price premiums could be justified on the grounds that they cover the additional costs incurred by organic farmers in avoiding damage to the environment (though in practice higher prices arise because of the demand for organic products relative to supply). But the difference between farm externalities for the organic compared with conventional food basket (81.2 less 19.45p = 61.75p) is very much smaller than the premium charged to consumers (£14.58 at supermarket; £8.59 at local scheme). One explanation is that retailers, manufacturers and/or farmers are charging more as they believe some consumers will pay more. The difference can only be partially explained as representing the value of on-farm natural capital being built by farmers through improvements to soils, biodiversity and landscape.

Transport to Retail Outlets

Vehicle transport imposes various environmental, social and health costs and these have been calculated for the UK in pence per vehicle km (p vkm^{-1}) for various types of vehicle and the cost categories of congestion, harm to health (noise, asthma), climate change (from greenhouse gases) and infrastructure damage (Nash and Salmon, 1999; Dodgson et al, 2002). These costs are shown in Table 17.4.

National statistics record three measures for freight transport: bn t-km travelled, Mt of goods lifted and vkm travelled, and all measures have increased in recent years (DLTR, 2002; EEA, 2003). Between 1980–1982 and 2000, bn t-km for all goods rose by 65 per cent to 149.3; Mt lifted by 23 per cent to 1580; and

Table 17.4 *Environmental and health costs (in pence) per vehicle kilometre for various modes of transport*

Vehicle type	*Costs (p per vehicle km)*
Car	11.95
Light commercial	13.71
Heavy goods vehicle (rigid)	31.57
Heavy goods vehicle (articulated)	42.92

Sources: Nash and Salmon, 1999; Dodgson et al, 2002 vkm by 41 per cent to 22.2 billion. Agrifood products (food, drink, tobacco, fertilizer) now account for 28.1 per cent, 28.1 per cent and 28.8 per cent of these totals respectively (up from an average of 25.1 per cent in 1980–1982). This is despite the fact that retail logistics are now claimed to be the most efficient in the world, with more centralized distribution centres, just-in-time stock management, factory gate pricing, information technology innovation, increased backhauling and more home deliveries (IGD, 2003; Garnett, 2003).

Adjusting for the proportion of freight transported in different size vehicles (16 per cent for 3.5–17t; 39 per cent for 17–33t; 43 per cent for >33t) (DLTR, 2002), the total externalities of movement to retail outlets of agricultural produce is calculated to be £2348 M yr^{-1}. This is equivalent to £39 $person^{-1}$ yr^{-1}, or 75.7p wk^{-1}. With farm externalities, this now increases the real cost of the weekly food basket to £26.37 (a 6.4 per cent increase).

National transport statistics already include a factor for empty running, more than a quarter (26.4 per cent) of all vehicles on the roads are recorded as running empty (DLTR, 2002). In addition, only 59 per cent of space is filled (the lading factor). Thus one tonne moved 1km effectively travels 1.69 (i.e. 1/0.59) × 1.264 = 2.14km, or each average km travelled carries only 46.7 per cent of total possible load. Thus, as 26.4 per cent of vkm are empty, some £619 M yr^{-1} of food mile costs could be avoided if vehicles were run to full capacity.

Domestic data do not include air, ship and truck transport from overseas sources. However, climate change contributed by this overseas transport does affect UK consumers and so data for carbon emissions from fossil-fuel consumption (C $t\text{-}km^{-1}$) (Gover, 1994; DLTR, 2002) and their marginal damage costs (Hartridge and Pearce, 2001) (£29.8 tC^{-1}, 2.98p per kg of carbon as C) were used to calculate additional climate change costs per t-km. A factor for congestion, health or infrastructure for overseas transport is not included, as they do not directly affect consumers in the UK.

The produce imported by sea to the UK amounts to 388 Mt yr^{-1}, of which food, drink and agricultural inputs are 18.6Mt. The costs per t-km for sea transport are 0.0082p $t\text{-}km^{-1}$ (for 2.74g C $t\text{-}km^{-1}$). Assuming a conservative average of 10,000km per trip (by ship, New Zealand is 23,000km distant, Australia 21,500km, California 16,300km, The Netherlands 100km and Denmark 1200km), then these 186bn t-km incur costs of £15.25 M yr^{-1}. These costs are very small (0.65 per cent transport of foods on domestic roads in the UK to retail outlets).

There are, however, concerns that air miles may be making a significant contribution to environmental costs. In 1998, there were 100 bn t-km of goods transported by air in 1998 worldwide (IPCC, 1999; Defra, 2001). UK airfreight (imports + exports) was 2Mt for 1998, of which imports of fruit and vegetables were only 0.114Mt yr^{-1}. For air trips, an average distance travelled of 8500km was assumed (South Africa is 9600km distant; New Zealand 18,800km; Chile 11,700km; Mexico 8900km; Zambia 7900km; Argentina 11,100km; California 8800km). With costs per t-km of 0.46p $t\text{-}km^{-1}$ (156 g C $t\text{-}km^{-1}$), then this gives a total of 0.97bn t-km and an external cost of £4.46 M yr^{-1}. If all airfreight travels in dedicated freight planes, then the full costs are incurred (every extra kg consumed requires extra space). But some airfreight is carried in the belly of passenger planes, so does not technically incur the full marginal cost – just the extra fuel required to haul the additional freight. Globally, 50% of airfreight is in the belly of passenger planes (Garnett, 2003) and so the external costs of air imports of fruit and vegetables is only £2.23 M yr^{-1}. Once again, this is trivial compared with the environmental costs of domestic transport (0.09 per cent of domestic road costs). However, it is important to note that if all of the weekly food basket were transported by air, then the additional environmental costs would become severe. It is only because of the low volume at present that these costs remain relatively low.

Transport of Food to Home and to Landfill

Once the food is at the retail outlet, consumers still have to transport it home for consumption. National statistics on shopping trips and the environmental costs of transport for cars, buses, walking and cycling were used to calculate the cost for shopping for food (Dodgson et al, 2002; Defra, 2002d). Each person in the UK made 221 shopping trips per year in 2000 (up from 210 in 1985–1986), with an average length of 6.4km (up from 4.6km), resulting in a total travel of 1414km yr^{-1} (up from 978km yr^{-1} in 1985–1986). Of these shopping trips, 58 per cent were made by car, 30 per cent by walking, 8 per cent by bus and 3 per cent cycle. The 221 trips are equivalent to 4.25 per person wk^{-1}.

Assuming that only half of trips are solely for food, and that food shopping is per household rather than per person (the food basket is per person and on average there are 2.32 persons per household), then 110.5 trips are made per household per year for food. As the average distance is 6.4km, these trips cover 706km yr^{-1} for food or 13.6km per week. Of these, 7.89km are by car (at cost of 11.95p vkm^{-1}), 1.09 are by bus (at 33.57p vkm^{-1}, but with 30 people per bus) and 4.49km are by walking and cycling (at zero cost). This gives a total cost for transport to home of 95.43p $household^{-1}$ wk^{-1}, 41.1p $person^{-1}$ wk^{-1} and an aggregate of £1275.7 M yr^{-1}.

Each person produces 74kg of domestic organic waste per year (Defra, 2002d). Each household throws away 3.29kg wk^{-1}, plus an additional 4.06kg wk^{-1} of food packaging, resulting in a total disposal of 9.8Mt yr^{-1}. As each garbage truck carries some 10t when compressed, and travels 23km from depot to pickup to landfill site (DLTR, 2001), then these loads at an environmental costs of 31.57p vkm^{-1} incur aggregate costs of £7.12 M yr^{-1} or just 0.002p $person^{-1}$ wk^{-1}.

The Issue of Subsidies

Subsidies can be seen to be part of the full cost of food, as they are payments from taxpayers to farmers. They are not externalities, but can exacerbate them by increasing output beyond that which would be dictated by market conditions. Public subsidies can be progressive, as the wealthy pay more tax than the poor, and the benefits of the subsidies are equally spread amongst food consumers (though some food production systems have not to date received public support, e.g. pigs, vegetables). Subsidies only have their full effect if they encourage the production of public goods (or positive externalities) that are available to consumers. But until 2004, formal subsidies have mostly supported agricultural production systems that give rise to adverse environmental effects and so must logically be seen as perverse. Annual support for organic farming amounted to £6–18 million per year for 1999–2000 and 2000–2001.

The average annual UK government subsidy for all agriculture in 1999–2000 and 2000–2001 was £3.102 billion (Defra, 2002c). We did not use data for 2001–2002 as this included an additional £2 bn for foot and mouth disease, giving a total of £5.26 bn. For each person in the UK, the £3102 M represents an additional cost of £52 yr^{-1}, or £1 per week. However, some £219 million of this total was used for rural development and agrienvironment schemes intended to create positive externalities (Defra, 2002c). Assuming that these are successful, we removed them from total costs to leave total subsidies of £2883 M yr^{-1}, which is equivalent to 93p $person^{-1}$ wk^{-1}.

The Full Costs and Scenarios for Cost-avoidance

Table 17.5 contains a summary of our estimates of the full costs paid by UK consumers for their food basket. The weekly food basket rises in cost from the £24.79 paid by consumers by £2.91 per person wk^{-1} (11.8 per cent), with farm externalities (81.2p), domestic road transport (75.7p), government subsidies (93p) and shopping transport (41.1p) contributing the most. Sea and air transport and transport to landfill are very small contributors to overall cost. This amounts to additional costs of £8045 million yr^{-1} to the whole food system.

This could be an underestimate of the full costs, as many environmental side effects in the food chain have not been assessed here. These include energy consumed by processors, manufacturers and wholesalers for light, heat, refrigeration and transport, disposal of food packaging, foods consumed by domestic pets, methane emissions from landfill and sewage waste, and the energy required for domestic cooking. In addition, we have not assessed the health consequences of the dietary choices made for the weekly food basket (Kenkel and Manning, 1999; Ferro Luzzi and James, 2000; Rayner, 2001; Wanless, 2004). Such diet-related ill

Table 17.5 *Summary of components of full costs of the UK food basket (average for 1999–2001)*

	Annual costs (£ M yr^{-1})	*Costs per person (p person^{-1} wk^{-1})*	*Proportion of total externalities*
Agricultural externalities	1514	81.2[1]	18.8%
Domestic road transport (from farm to shop)	2348	75.7	29.2%
Sea, internal water and air transport for imports	17	0.005	<0.01%
Shopping (from shop to home)	1276	41.1	15.8%
Waste disposed to landfill	7	0.002	<0.01%
Total externalities	5162	198	
Government subsidies	2883	93	
Price paid for food basket (including eating out)	89,500	2479	
Full cost of food basket (total externalities and subsidies)	8045	291	—
Full cost (including externalities and subsidies)	97,545	2770	—

Note: 1. The agricultural costs per person are not simply annual costs divided by population, as account has been taken of imports and exports to and from the UK.

health is costly, but clearly not a direct consequence of types of agricultural systems.

Another source of error arises from recent changes in farm practices, with many farms adopting environmentally-sensitive practices in recent years, and so our estimates of environmental costs may be too high. At the same time, transport distance to retail outlets and by shopping is increasing and so these costs may be underestimates. A further source of uncertainty arises from the comparison of organic and conventional systems, as we have relied on assumptions that certain practices would guarantee certain environmental outcomes. This may not prove to be true, for example, if organic farming were to be much more widespread than at present.

An important policy question centres on what might be done to avoid some of these costs through adoption of more sustainable methods of food production, localized food systems and more sustainable methods transport, such as substituting bus for car, ship for air, rail for road, and reducing empty running and unfilled vehicles.

We calculated the benefits of various scenarios for changes in farm practice, transport to retail outlets, transport to home and for waste disposal (Table 17.6). If the food basket were all organic and subsidies all used for agrienvironmental

Table 17.6 *Avoided costs under different scenarios for adoption of organic farming, localized food systems and more sustainable transport options*

Scenarios	*Current external costs (£M yr^{-1})*	*Revised total external costs under each scenario (£M yr^{-1})*	*Revised per capita external costs under each scenario (p $person^{-1}$ wk^{-1})*	*Avoided costs with new farm and/or transport strategies (£M yr^{-1})*
A. Farm externalities				
A1. All farms organic (from Table 17.1)	1514	385	19.5	1129
B. Transport to retail outlet				
B1. Local food system (all less than 20km)[1]	2348	229	7.4	2119
B2. National with maximized rail[2]	2348	842	27.2	1506
B3. All continental Europe[3]	2348	3374	108.8	(1026)[10]
B4. All global ship[4]	2348	2712	87.4	(364)[10]
B5. All global air[5]	2348	19,708	636.1	(17,360)[10]
C. Transport to home				
C1. Shopping all by cycle/walk[6]	1276	0	0	1276
C2. Car shopping replaced by bus[7]	1276	126	4.1	1150
C3. Car and bus replaced by home delivery[8]	1276	549	17.7	727
D. Waste				
D1. All organic material composted[9]	7	0	0	7

Notes:

1 All of food basket sourced from within 20km of retail outlet.

2 80% of food travels by rail (with zero congestion costs) and 20% by road, and that costs are 56g C t-km^{-1} by road (large truck) and 11.1 g C t-km^{-1} by rail.

3 All food sourced within continental Europe, travelling an average of 1500km, then 444Mt (at 25t carried per vehicle) would require 17.76 M vehicles to travel 26,640 M km yr^{-1}; and using an external cost of 1.8p t-km^{-1} (just climate change costs are included, as congestion, health and infrastructure damage occurs elsewhere in Europe) and multiplying by the ratio of 2.14 (for empty running and lading factor).

4 All food imported by sea and that 10,000km travelled, then 4440 billion t-km would be carried at 0.0082p t-km^{-1}.

5 All food imported by air and that 8500km travelled, then 3774 billion t-km would be carried at 0.46p t-km^{-1}.

6 Cycling and walking incur no transport externalities (we do not count the health benefits of exercise here).

7 All current car transport replaced by bus (and 33% still by walking and cycling).

8 All car and bus transport replaced by home delivery and assuming a 60km round trip once per week to 20 households, and costs for LDVs at 13.71p v-km^{-1}.

9 All organic food waste is composted at the home.

10 (brackets) indicates an increase in costs.

Table 17.7 *Comparison of various transport scenarios for conventional and organic food baskets*

	Total cost of individual food basket (price + externalities) (£ wk^{-1})	*% increase in total cost over price paid*	*Saving per person over current full costs (£ wk^{-1})*
Total current food basket costs (price + externalities arising from conventional agriculture, national and car transport, waste to landfill and subsidies)[1]	£27.71	11.8%	–
Current food basket with different transport scenarios			
+ local food + walk/cycle	£26.60	7.3%	£1.11
+ local food + home delivery	£26.78	8.0%	£0.93
+ local food + bus	£26.65	7.5%	£1.06
+ national road + car	£27.70	11.7%	£0.01
+ national rail + bus	£26.84	8.3%	£0.87
+ continental Europe + car	£28.03	13.1%	(£0.32)
+ global air + car	£33.30	34.3%	(£6.59)
All organic food basket with different transport scenarios			
+ local food + walk/cycle	£25.06	1.1%	£2.65
+ local food + home delivery	£25.24	1.8%	£2.47
+ local food + bus	£25.10	1.3%	£2.61
+ national road + car	£26.15	5.5%	£1.56
+ national rail + bus	£25.30	1.2%	£2.41
+ continental Europe + car	£26.48	6.8%	£1.23
+ global air + car	£31.76	28.1%	(£4.05)

Note: 1 From Tables 17.4 and 17.5.

purposes (as can eventually be expected following the reform of the Common Agricultural Policy), and that food were locally sourced or predominantly transported by rail and then transported home by walking/cycling, bus or home delivery, then external costs would fall from 11.8 per cent of the food basket to 1.1–1.8 per cent, saving each person in the UK £2.41–2.65 wk^{-1}. The saving would be less if the food basket was all conventional (Table 17.7). If all food were sourced within 20km of homes or other places of consumption, then we estimate that £2119 M of environmental costs would be avoided.

But if an entirely organic food basket was sourced from continental Europe and transported by current transport modes, then the avoided costs to the farm gate would be offset by the transport costs (though any farm costs would be incurred outside the UK). Furthermore, produce entirely globally sourced by air would increase the price to each person by an additional £4.05 wk^{-1} if it was organic and £6.59 wk^{-1} if conventional (Table 17.6). Some £1276 M of costs would be avoided if all food shopping were by cycle or walking; £1150 M avoided if cars were replaced with public transport; and £727 M avoided if car and bus were replaced by home delivery schemes.

These scenarios, although they are unlikely to arise entirely, do indicate the scale and relative contributions to the weekly food basket of various components of the food chain. The data suggest that degrees of local-ness might be more significant than previously considered. They also indicate that consumers' decisions on specific choices of food (here organic versus conventional) and transport can have an important affect on farm systems and the environment, and will be an important consideration in future policy reform. The data further indicate the value of domestic garden and allotment produce, as such food production incurs low to zero farm externalities and effectively zero transport externalities (allotments currently produce 0.22Mt yr^{-1} of fruit and vegetables, compared with 3.17Mt produced on farms).

Concluding Comments

We have calculated the environmental costs of the UK food basket and found that farm externalities, domestic road transport to retail outlets, domestic shopping transport and subsidies are the main contributors to the estimated hidden costs of £2.91 per person per week (11.8 per cent more than the price paid). It is clear that actions to reduce farm and food mile externalities and shift consumers' decisions on specific shopping preferences and transport choices would have a substantial impact on environmental outcomes. The potential for food and transport businesses and governments to reduce these externalities would appear to be considerable. The key policy questions now centre on how best to do this using a variety of taxation, incentive and regulatory mechanisms. It will be important to ensure that agriculture and food policy reforms continue to result in the production of safe and nutritious food whilst also maximizing the production of positive externalities.

The most likely scenario for the immediate future is 'business as usual' with some incremental change. It could be, however, that external shocks institute more radical change. Such potential shocks range from another energy or oil crisis to the realization of the seriousness of climate change or of the immense costs of current systems such as we outline here.

However, localization of food systems, such as we point to here, would require changes in the behaviour of actors and businesses across the whole supply chain, with localized geographic areas needing different patterns of land use to supply local markets and consumers. Some of these changes may lead to trade-offs and losses in overall system sustainability, or possibly losses in jobs in the freight or input supply industries. In addition, proximity alone may not be a good measure of sustainability, as a long journey on water has a lower impact than a shorter one by road. At the same time, though, globalizing trends in food systems are likely to continue, making localization harder and less likely to occur, despite the net economic benefits.

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18

French Quality and Ecolabelling Schemes: Do They Also Benefit the Environment?

Genevieve Nguyen, Thomas L. Dobbs, Sherry K. Bertramsen and Bruno Legagneux

Introduction

Facing a major agricultural crisis, European countries are searching for alternatives to the intensive-production agricultural development model promoted since the early 1950s. Agenda 2000 introduced significant changes in the Common Agricultural Policy (CAP) by recognizing the multifunctionality of agriculture and by giving more importance to the 'second pillar', a term used to qualify all the measures to support rural development (Delorme, 2004; Ledent and Burny, 2002). Meanwhile, agrienvironmental schemes are taking on much greater importance in the overall policy mix for agriculture in European Union (EU) countries. Various schemes have been tried over the last 15 years, and new ones are being introduced in such countries as the UK (Dobbs and Pretty, 2004) and France (Miclet, 1998). The adoption of environmental schemes by French farmers has been somewhat successful, but farmers often have high opportunity costs and their decisions are driven primarily by economic considerations (Gafsi et al, 2002; Miclet, 1998). Policy makers now face substantial challenges to increase the adoption of environmental practices.

In France, there is a fairly long history of food 'quality' schemes. 'Quality' is used in the French context to denote taste, healthfulness and conditions of production. Two of the best-known French quality schemes are the Appellation d'Origine Contrôlée (AOC, controlled origin label) and the Label Rouge (LR, or Red Label) schemes, created respectively in 1919 and 1965 (Agreste, 2003). 'Eco-labelling' is a more recent phenomenon in both Europe and North America. Eco-labels are meant to provide consumers with information about a product's environmental impact. Often these labels contain information about the production process of the product,

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as does organic labelling (Agriculture Biologique, in France). Both types of labelling schemes are gaining in importance for food products on both sides of the Atlantic. In comparison to environmental schemes, farmers in France tend to engage more easily in food quality schemes because of the price premiums consumers are often willing to pay for quality products. Although the standard guidelines of food quality schemes do not include any environment guarantees, consumers tend to associate quality food products with environmentally friendly farming practices, partly due to unclear market signals (Pujol and Dron, 1998).

As France, other EU countries, North America and other parts of the world place greater emphasis on schemes which reward farmers for environmental stewardship – both through the market and through government stewardship payments – it is important to know whether these 'quality' and 'ecolabelling' schemes do, indeed, provide measurable environmental benefits. If they do, policies can be implemented to foster and encourage these schemes, in which some portion of the incentive for farmer adoption comes through price premiums. Otherwise, a policy conclusion might be that though the schemes have possible health, taste or other consumer benefits, they should not be relied on for substantial environmental benefits. An alternative possible policy conclusion is that perhaps the criteria for eligibility and certification with these schemes should be broadened or strengthened to bring about greater environmental benefits.

In his theoretical analysis of the relationship between food quality and environmental quality, Thiébaut (1995) points out three possible levels where the relationship can be observed:

- at the *territorial level*, there can be joint production of final quality food products and environmental services (e.g. wine and landscape);
- at the *farmer's level*, there can be simultaneous production of quality food products and environmental goods (e.g. positive externalities or reduction of negative externalities);
- at the *consumer's level*, there can be joint demand for quality food and protection of the environment.

Kephaliacos and Robin (2003) suggest another way to look at the relationship between food quality and environmental quality. They suggest analyses at the *input level* (e.g. not allowing certain joint inputs) and at the *output level* (e.g. the nature of interdependencies between the quantities or characteristics of the outputs). Our study's main objective was to analyse the extent of the relationship between food quality and output quality at the farmer's level by looking at the production process and at the nature of the outputs.

Girardin and Sardet (2002) examine the potential environmental output effects of eight different sets of standards proposed for European farmers. By examining the nature of the input level standards (rather than using data from actual farms), they found 'organic agriculture' and 'integrated production' to have relatively high potential for producing positive environmental outputs. Although other standards examined had some positive aspects, they appeared not to have sufficient potential for improving environmental quality on arable lands (Girardin and Sardet, 2002).

Van Ravenswaay (1996) studies some of the challenges facing environmental labelling. She notes that environmental labelling has created two controversies. They involve (1) the potential for consumer deception, and (2) whether environmental labels should also serve environmental policy objectives. Consumers' ability to discern whether or not a product has been produced in an environmentally sound manner remains tenuous (Erickson and Kramer-LeBlanc, 1996). Lohr (1998) notes that there are many certifications – in addition to organic – for environmentally oriented production systems. She indicates that although consumer interest in purchasing food products with 'green' production characteristics is growing, given that existing ecolabels are not well-defined in consumers' minds, there is substantial potential for new labels with vague criteria that are not legally defined to generate confusion. Thiébaut (1995) articulates the additional problem of determining whether specially labelled products contribute to both 'internal' quality (e.g. taste) and 'external' quality (production of positive environmental externalities or reduction of negative ones).

For purposes of public policy analysis, it is useful to view labelled products from the standpoint of 'multifuntionality'. Agriculture is capable of producing food and fibre outputs, social outputs (e.g. rural employment opportunities and 'equitable' income) and environmental outputs. Many of the social and environmental outputs have 'public good' or 'externality' characteristics (Bougherara and Grolleau, 2002; Dobbs and Pretty, 2004). Policy issues associated with agricultural systems engaged in producing quality and ecolabelled products are twofold:

- Do the criteria established for particular labels, including labels originally developed for social reasons (such as territorial development), also effectively contribute to agriculture's environmental function?
- To the extent labelled products do provide positive environmental outputs, are those outputs types that consumers are willing (or might be induced) to provide compensation for in the market through price premiums? As environmental awareness and income levels rise in societies, a growing number of consumers may be willing to pay some price premium for environmental outputs that are essentially public goods or externalities. However, that willingness is likely to vary with the type of environmental output, and it is unlikely ever, by itself, to be adequate to induce socially optimal levels of environmental quality across the full range of environmental outputs potentially associated with a truly multifunctional agriculture.

Although farmers themselves have multiple goals – including stewardship and risk management goals – farm profitability is always one of the important goals that agrienvironmental policies must address. Therefore, policies will need to consist of a mix of schemes that both (1) facilitate enhanced market value for food and fibre products which result from farming systems that jointly produce environmental goods, and (2) provide non-market or extra-market incentives for a multifunctional agricultural system that enhances environmental quality.

The main objective of this chapter is to examine whether the production of quality food was associated with the production of any environmental benefits. The chosen study area is the Midi-Pyrenees region of south-west France, well-known for the diversity of farming systems and the importance given to the promotion of quality food schemes. Statistical analyses based upon data collected for a random sample of 107 farms are conducted to identify correlations between farms' environmental scores and their level of participation in major 'quality' and 'ecolabelling' schemes in use. These results are complemented by qualitative results drawn from in-depth case studies of five food quality schemes. Policy implications are presented in the last section of the paper.

Quality and Ecolabelling Schemes Examined[1]

One 'ecolabel' and three 'quality' categories were examined in this study. The ecolabel included in the study was Agriculture Biologique (AB), organic agriculture. France officially recognised organic agriculture in 1980, and allowed farmers to use the label 'product made from organic agriculture' and created public standards to regulate the industry (MAAPAR, 2001). Although we refer here to the French AB as an 'ecolabel', in reality, it has always been considered a regular food 'quality' label like others described below. Most French consumers think that the AB label guarantees not only the non-use of chemical inputs, but also the taste and health of the resulting food product (Loisiel and Couvreur, 2001; MAAPAR, 2004; Pujol and Dron, 1998).

The different quality label categories included in the study are:

(1) The *Official Sign of Quality (SOQ)*. SOQ products receive an official government label that requires producers to follow specific guidelines for production of the product. Included in this category are the Appellation d'Origine Contrôlée (AOC) and the Label Rouge (LR).[2] The French controlled origin label was established in 1919 for the wine sector. It then spread to milk products and, in 1990, to all other agricultural food products. The AOC label implies more than horizontal differentiation; it also testifies that the product has been produced from local raw products in a place-specific mode, and that its high quality characteristics are the result of substantial long-term collective and individual investments (Kilkenny and Daniel, 2001). The LR was created for products that possess specific characteristics and enjoy a superior level of quality that distinguish them from other similar products (MAAPAR, 2001). It guarantees a better taste and high standards of production, while the AOC guarantees primarily the origin of the product. The LR is a nationwide structure that ties highly

localized groups of producers and their supplier and processing networks together to deliver consumer products that differ from industrial products. The differences supposedly are distinguishable with regard to intrinsic quality, food safety, environmentally sound production practices and product image (Westgren, 1999).

(2) The *Other Cahier des Charges (CDC)*. These products are not under an official government label, but they are produced in a quality way under specific guidelines from a cooperative, supermarket or agricultural supplier. The CDC is the formal document that specifies the agreed production guidelines.
(3) The *Official Sign of Quality of Transformed Food (SOQT)* products. While SOQ products concern raw materials, the SOQT category pertains to the outputs of food industries, including cooperatives. It includes the LR and the AOC. The guidelines do not directly concern farmers; instead, they apply to processing or manufacturing of food. An example of this designation is AOC Roquefort. The quality label specifics the cheese's production process, rather than the process of producing the milk.
(4) The *In Process (IP)* category. Producers in this category were just starting to switch over to an ecolabel (AB) or quality (SOQ, CDC or SOQT) approach.

Data and Methods of Analysis

Data analysed in this study were collected by researchers from three different agencies – SOLAGRO (a private agricultural and environmental association), the Regional Chamber of Agriculture of the Midi-Pyrenees and the Department of Agriculture of the Haute-Garonne. The data were made available to a research team at the École Nationale Supériere Agronomique de Toulouse (ENSAT), in France. The original data set contained information on farmers' practices and factors that could be scored from an environmental standpoint. Farmers were called and asked if they were involved in any agrienvironmental schemes, ecolabelling programmes and quality labelling programmes. The usable data set covered 107 farm operations in the Midi-Pyrenees region of the south-west of France. The categorization of these farms is shown in Table 18.1. Fifty of those farms were participating in one of the eco- or quality-label programmes (including three that were IP). Farms being randomly sampled, the unequal distribution of the 50 farms across the different schemes corresponds to the distribution observed within the total population of farms in the Midi-Pyrenees region, where about three-quarters of the farms participate in the SOQ schemes (excluding AB).

Table 18.2 constitutes a glossary of environmental scores used in the analyses. This is not an exhaustive list of the environmental scores that were recorded for farms in the data set, but the list does include the scores most often used in our analyses. Environmental scores consisted of eight components. One set of aggregate scores (PS1 and PS2) was based on two broad components: (1) overall diversity of

Table 18.1 *Distribution of farms by quality code*

Quality code	*Quality approach*	*Number of farms*
AB	Organic agriculture (AB)	8
SOQ	Official sign of quality (AOC, LR, CCP)	25
CDC	Other cahiers des charges	9
SOQT	Official sign of quality of transformed food	5
IP	In process	3
N	Nothing	57
Total		107

production; and (2) appropriate use of inputs such as synthetic chemical fertilizer. A second set (PE1 through PE6) was based on a more detailed breakdown, consisting of six components: (1) water use; (2) soil fertility and erosion; (3) plant and animal diversity; (4) air quality (e.g. emissions of greenhouse gases); (5) resource consumption (e.g. net production of renewable energy); and (6) waste management. Analyses were carried out using various individual components and combinations of components.

The database includes other variables on the characteristics of the farms, including size and types of production. Farm size variables referred to in the Results section below are defined as follows: (1) SAU, score equal to one full-time employee on a farm; (2) UTH, number of hectares on the farm; and (3) MBS, an index of the economic size of a farm (a measure of the difference between the regional standard value of all production on a farm and the regional standard production costs).

Using the Statistical Package for the Social Sciences (SPSS), we carried out both factor analyses and analyses of variance to determine the correlation between a farmer's participation in any of the ecolabelling and quality labelling schemes and the environmental score of his or her farming system.

For purposes of statistical analyses, ecolabelling and quality approaches were ordered from presumed least environmental impact to presumed highest environmental impact, based on the level of environmental quality that each approach was thought to demand. Farmers not participating in any ecolabelling or quality approach were assigned a rank of 1 (one), IP farmers were given a 2 (two), those following an SOQT approach were given a 3 (three), those following a CDC approach were given a 4 (four), those following an SOQ approach were given a 5 (five) and AB farmers were given a 6 (six). This ranking was based on an inventory of environmental practices mentioned in the different quality schemes standard guidelines, discussions with agricultural technicians and experts, and conclusions drawn from diverse field studies (Bourdais, 2001; Pujol and Dron, 1998).

In order to complement the above quantitative results and to get more insight on the nature of the relationship between quality practices and environmental practices, in-depth interviews were conducted with 85 randomly sampled farmers

Table 18.2 *Breakdown of environmental scores used in the SOLAGRO's environmental diagnosis tool DIALECT*

PART 1 – A global approach of the farming system with two scores adding up to 100
PS1: This score, worth 70 points in total, defines the mix of the farm and the diversity of production. It includes plant diversity (30 points), animal diversity (22 points) and natural elements and space (18 points).
PS2: This score, worth 30 points, defines the rational use of inputs on the farm. It includes the use of nitrogen (7.5 points), phosphorus (3.0 points), water (6.0 points), phytosanitaries (7.5 points) and energy (6.0 points).
PART 2 – A thematic analysis of the impact of agricultural practices on different elements of the environment (water, soil, biodiversity, air, energy and inputs, waste)
PE1: This score, worth 100 points, describes the quality and quantity of water used on the farm. It includes nitrogen discharges (14 points), phosphorus discharges (14 points), management of water (14 points), phytosanitary residue (15 points), effluent discharges (14 points), protection by organization of farm space (15 points) and protection by natural elements (14 points).
PE2: This score, worth 100 points, describes soil fertility and erosion. It includes management of organic material (35 points), risk of erosion (45 points) and quality of soil and pollutants in the soil (20 points).
PE3: This score, worth 100 points, describes plant and animal diversity on the farm or ranch. It includes natural elements (25 points), permanent prairies that are not fertilized very much (20 points), spaces with weak potential, such as dry or wet areas (10 points), zones of biological interest (15 points), absence or limited use of pesticides (20 points), threatened animal breeds (5 points) and old varieties of plants (5 points).
PE4: This score, worth 100 points, describes the quality of air on the farm or ranch. It includes emissions of greenhouse gases (35 points), emissions of ozone-depleting and acetic gases (15 points), emissions of phytosanitaries (25 points), odour nuisances (10 points) and production of oxygen (15 points).
PE5: This score, worth 100 points, describes the consumption of resources on the farm or ranch. It includes direct energy consumption (20 points), indirect energy consumption (15 points), phosphates purchased (15 points), potassium bought (15 points), water consumed (15 points) and net production of renewable energy (20 points).
PE6: This score, worth 100 points, describes the storing and handling of waste on the farm or ranch. It includes the handling and storing of dangerous wastes (50 points), the handling and storing of potentially dangerous wastes (20 points) and the handling and storing of plastic and metal wastes (30 points).

participating in five quality programmes: (1) CCP[3] 'Covapi' (apples); (2) AOC 'Chasselas' (raisins); (3) CCP-1GP 'Melon du Quercy' (melons); (4) LR 'Poulet Roux du Gers' (chickens); and (5) LR 'Veau de l'Aveyron et du Ségala' (calves) (Allhoff, 2002; Carton et al, 2002; Teynier, 2002). These farmers, all located in the Midi-Pyrenees region, were questioned about the characteristics of their farm, their motivations to engage in a quality scheme, their quality and environmental practices, and their perception of environmental problems. Information on the farmers' quality organizations and guidelines also were collected in order to analyse the extent to which recommendations on environmental practices were included in the organization's rules and guidelines.

Results of Statistical Analyses[4]

Farm size and adoption of environmental practices

A factor analysis was conducted to identify groups of farmers that share similar characteristics – such as high environmental grades, size of farm, income, ecolabel or quality approach followed, or number of workers – and to determine if either large or small farms tend to be associated with high total environmental scores or if either large or small farms are especially likely to be involved in quality or ecolabelling schemes. Four distinct clusters were identified in this analysis (Figure 18.1). One cluster (cluster A) was composed of farmers with relatively small farms, low

	Total variance explained by each component	
	F1 40%	F2 30%
	Component Matrix	
Quality code	.057	.841
SAU	.740	–.268
UTH	.789	.352
MBS	.884	.036
PS1 + PS2	–.209	.763

Extraction Method: Principal Component Analysis

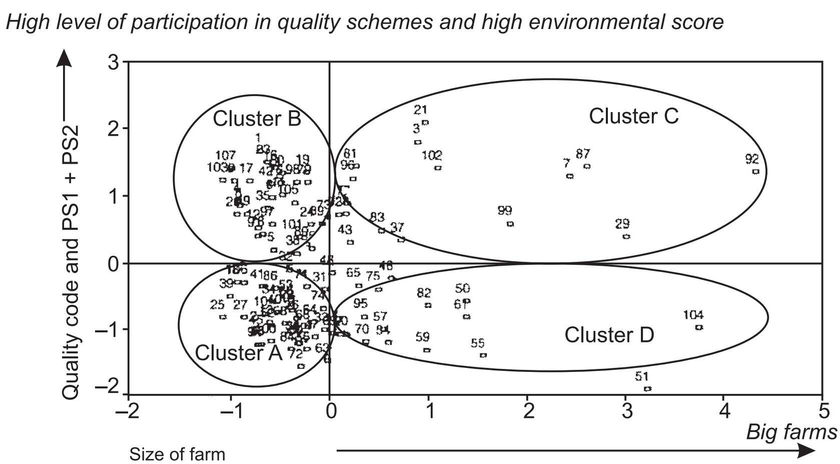


Figure 18.1 *Factor analysis of quality codes, SAU, UTH, MBS and PS1 + PS2*

environmental scores (PS1 + PS2) and a low level of participation in quality and ecolabelling schemes (i.e. not participating at all, IP, or participating in a scheme thought, a priori, to provide less environmental benefit than some others). Another cluster (cluster B) also was composed of relatively small farms, but these farms had high total environmental scores and participated in schemes thought, a priori, to provide greater environmental benefits (e.g. AB). Larger farms were split in a similar fashion, with about half (cluster C) engaged in higher-level quality or ecolabelling schemes and having high environmental scores, and the other half (cluster D) having low total environmental scores and participating in no or lower-level quality and ecolabelling schemes. The importance of environmental practices does not appear to be correlated with the size of the farm. However, on average, large and small farms participating in a quality scheme have significantly higher environmental scores than the non-participating farms.

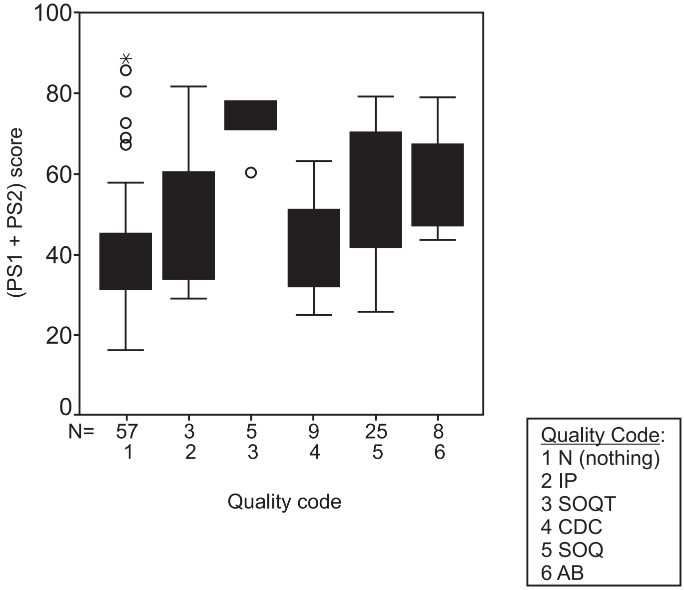
Farm production specialization, type of quality or ecolabel and adoption of environmental practices

Analysis of variance (ANOVA) tests were then run to determine if particular quality and ecolabelling schemes were associated with the various environmental indicators:

(1) Comparison of quality and ecolabelling schemes on the basis of mean aggregate environmental scores using the first set components 'PS1 and PS2' reflecting a global approach of the farming system.

Farmers participating in SOQT schemes had the highest mean score and farmers involved in AB and SOQ programmes were next highest, but substantially below the mean for SOQT farmers (Figure 18.2). This high mean environmental score for farmers in SOQT could be explained by the fact that the majority of them raise sheep and produce milk for the labelled cheese products, based upon extensive farming systems with a minimum of negative environmental impact. The types of farming systems they use have direct effects on environmental scores independent of farmers' adoption of particular environmental practices. Farmers not involved in any ecolabel or quality programmes, as expected, had the lowest average aggregate environmental scores, but that score was only slightly lower than the average for farmers in CDC schemes. The mean environmental score for SOQT farmers was significantly higher (at the 5 per cent level) than the mean scores for farmers in all other categories – including farmers not participating in any quality or ecolabelling programmes (symbolized by N) – except for farmers in the AB and IP categories.

(2) Comparison of quality and ecolabelling categories with respect to mean environmental scores based on the sums of individual thematic components PE1 through PE6.



F-test

PS1 + PS2

	Sum of squares	df	Mean squares	F	Sig.
Between groups	8377.616	5	1675.523	6.766	.000
Within groups	25011.52	101	247.639		
Total	33389.13	106			

Figure 18.2 *ANOVA for quality codes and PS1 + PS2*

N farmers again had the lowest mean score, but in this case AB farmers had the highest score. This is what was originally expected. SOQT farmers, as in the first test, performed relatively well environmentally, better than IP and SOQ farmers. Once again, CDC farmers did not perform as well as farmers in other quality and ecolabelling programmes. Multiple comparisons of the mean scores show that AB farmers performed significantly[5] better than farmers in all other categories except for those in the SOQT and IP categories.

(3) Three additional ANOVA analyses conducted in which quality and ecolabel categories containing a limited number of observations were combined. The N, AB and SOQ categories remained separate, but the SOQT, CDC and IP categories were combined into a new category labelled O, for others.

- A first ANOVA was conducted with this grouping to examine the relationship between quality/ecolabel categories and farm size, as measured by the MBS variable. Results indicate that the AB farms are smallest in terms of this economic 'value added' measure, and SOQ farms are the largest. Farmers not involved in any quality or ecolabelling programme are the second largest, on average, by this measure. The mean differences between SOQ farms and farms in all other categories are significant, but the differences between farms in the other categories are not significant. The relatively high value for economic output on SOQ farms was not unexpected, because products with SOQ labels, including those with the LR, often generate substantial price premiums. Westgren (1999) indicated that LR products can command prices up to 300 per cent over conventional prices. It was somewhat surprising that AB farmers had the lowest mean MBS value. However, the MBS index is more an indicator of farm size than of the real level of farm income. Organic farmers in the study had fewer hectares under production, on average, than did SOQ farmers.

- A second ANOVA, with the same quality category grouping, was conducted to isolate effects on soil fertility and erosion, as measured by PE2. AB, SOQ and O farms had significantly better PE2 performance, on average, than did farms not participating in any of these programmes.
- Farms participating in quality and ecolabelling programmes also performed significantly better, on average, on the environmental indicator for plant and animal diversity (PE3) than did non-participating farms. AB farms performed best, but not significantly better than SOQ and O farms.

Results of Qualitative Analyses

A sample of 85 farmers participating in five selected quality schemes were questioned about their motivations for adopting environmental practices. The analysis of their answers suggested that the relationship between food quality and the environment appears mainly through inclusion in the SOQ guidelines of environmental practices. These have an impact on the quality and the image of the product and that can send a clear signal to consumers. The environmental practices include reduction in the use of chemical inputs, preservation of natural habitats in fields, preservation of the land's natural characteristics, and respect for animal well-being. The guidelines of the CCP 'Covapi', LR 'Poulet Roux du Gers', and 'Veau de l'Aveyron et du Ségala' do, indeed, include explicit recommendations on environmental preservation and animal well-being. In contrast, the AOC 'Chasselas' and CCP-IGP 'Melon du Querey' guidelines were based on pre-existing farming practices (Table 18.3). For example, the list of chemicals a farmer can use is no stricter than the European norms. The quality approach only requires these fruit producers to reduce the number and the period of the treatments. Farmers participate in quality schemes for economic reasons first.

Table 18.4 gives some indication of the price premiums farmers can get from quality products. Farmers do receive a higher price for quality products, but the price difference is not always sufficient to cover costs associated with the labelling process. Only farmers producing top quality AOC 'Chasselas' and having a 100 per cent

Table 18.3 *Selected qualitative results of the study of five SOQ schemes*

	LR 'Poulet Roux du Gers' (poultry)	*LR 'Veau de l'Aveyron et du Ségala' (calves)*	*CCP 'Covapi' (apples)*	*AOC 'Chasselas' (raisins)*	*CCP-IGP 'Melon du Quercy' (melons)*
Type of participation in the quality scheme	Through the cooperative	Through the cooperative	Individual	Individual	Individual
Motivations of farmers to participate in the scheme	Economic (value-added + better conditions of work)	Economic (value-added, reduction of market risks and price variations)	Economic (value-added)	Economic (value-added, market niches, luxury products)	Economic (value-added)
Environmental practices specified in guidelines	Animal well-being: building norms, number of animals per unit of surface, planting of plants to provide shade	Animal well-being: building norms, number of animals per unit of surface	Reducion of chemicals Preservation of biodiversity Preservation of the soil's characteristics	None	None
Any additional environmental practices adopted independently of the guidelines		Improvement of the farm's surrounding: management of waste, preservation of the natural environment	Reduction of the traditional practice of cutting trees to accelerate fruit maturation		
Sensitivity of farmer to environmental issues	No	Yes, important to improve the image of agriculture and attract tourists	Yes, important to improve the image of the product for consumers and to improve the quality of life	Yes, but independently of the quality approach	Yes, but independently of the quality approach
Additional factors contributing to the adoption of environmental practices		Dynamism of the farmer SOQ organization (collective action)	Role of the SOQ organization's technicians		

Table 18.4 *Price differences between quality and standard products*

*Quality approach**	*Average price of quality products** (Euros/kilo)*	*Average price of standard products (Euros/kilo)*	*Range of price differences (%)*
AOC 'Chasselas'	1.22	0.68	32–178
CCP-IGP 'Melon Quercy'	0.65	0.53	11–33
LR 'Veau de l'Aveyron et du Ségala'	2.66	2.47	9–12

* Prices were not available for the CCP 'Covapi' and LR 'Poulet Roux du Gers'.
** Sale price received by farmers (data collected in 2002).

price premium consider the quality approach profitable. Nevertheless, the schemes allow farmers to occupy specific market niches and they do, indeed, help assure a minimum income. This was particularly true for farmers producing the LR 'Veau de l'Aveyron et du Ségala' during the BSE crisis. Farmers' sensitivity to environmental concerns may grow, however, as a result of having to follow the environmental guidelines embedded in the schemes.

The extent of changes in farming systems and practices induced by quality guidelines varies with the scheme. The respect for animal well-being required of poultry producers under the LR 'Poulet Roux du Gers' or the LR 'Veau de l'Aveyron et du Ségala' label mainly involves certain building specifications and small changes in breeding practices. In contrast, changes in fruit production practices could be significant in the case of the CCP 'Covapi' label, because farmers have to adopt new chemical and other production practices. In this case, farmers tend to become more sensitive to environmental issues and naturally develop new environmental practices independently of the label guidelines. Technicians for the quality organizations play an important role in developing farmer sensitivity to environmental issues.

The analysis revealed two other major determinants of the adoption of environmental practices by farmers: the impact of these practices on the farm's productivity and the opportunities for their monetary reward. We observed that certain environmental practices have been adopted because they help reduce yield risks or lower operating costs. Farmer behaviour towards the environment is also very dependent on consumer attitudes. It is easier for farmers participating in the CCP 'Covapi' to stop using chemicals because they can be compensated by a price premium consumers sensitive to healthy products are willing to pay. Similarly, to improve their image to consumers and make their territory more attractive for tourism, farmers participating in the LR 'Veau d'Aveyron et du Ségala' have decided, in addition to satisfying the SOQ guidelines, to preserve the natural environment surrounding their farms. Farmers selling products directly to consumers – like 'Covapi' fruit producers or producers of 'Veau d'Aveyron et du Ségala' meat – will, indeed, be more sensitive to environmental concerns due to their close contact with consumers. The difficulty in commanding price premiums for environmental practices less visible to consumers in quality schemes makes those practices less attractive to farmers.

Policy Implications

This research showed that organic farms and farms enrolled in various quality labelling programmes in France do provide some environmental benefits to society. However, they do not necessarily perform better than other farms on all environmental measures. This is not surprising for French food quality labels, as most of those labels were not originally designed for environmental purposes. Originally, most were intended to enhance marketability through appeals to such consumer values as taste and health. Conversely to consumer common opinion, the production of quality food is not necessarily associated with the production of environmental benefits. Yet, the policy question remains how to bring farmers to adopt environmental practices using market mechanisms and, in particular, consumer willingness to pay for a price premium to get higher global quality products.

There do appear to be opportunities to strengthen certification criteria to enhance environmental quality provided by the various French labelling schemes by explicitly including some environmental requirements in the food quality production standard guidelines. However, building environmental objectives into the certification criteria for products carrying regional and quality labels does not assure that the added social value will be reflected in higher market prices, due to the public goods and externality problem discussed in the introduction to this article. Bougherara and Grolleau (2002) suggest ways to enhance possibilities for at least some of this added value to be reflected in prices farmers receive. Third-party involvement in establishing and verifying environmental criteria is one important step in establishing credibility with consumers. Most private labels in our study (those in the CDC group) do not have such third-party involvement and, as indicated in our study results, farms with products carrying those labels tended to have lower overall environmental performance than did farms producing products with government sanctioned labels.

There have been a few efforts by farmer organizations in France to develop specific 'ecolabels'. These are commercial labels, not SOQ labels. They are, for the moment, too new to provide specific lessons. However, ecolabels may not constitute an efficient signal to consumers about farmers' environmental stewardship, due to an asymmetric information problem associated with the great increase in the number of all sorts of official and non-official quality labels. It is difficult for consumers to access and understand all the guidelines and to sort out the highly heterogeneous guidelines regarding prescribed environmental measures and their likely efficacies. As the EU continues with reforms in its CAP, a critical issue is what mix of government direct payments and market mechanisms to use in fostering expanded use of environmental practices. The resolution of that issue depends greatly on the extent to which quality and ecolabels can send clear and reasonably reliable market signals to consumers who are willing to pay for environmental goods provided jointly with food products.

Due to the problem of information overload, an ecolabel's success in the marketplace also depends on its ability to capture consumers' attention (Bougherara and Grolleau, 2002). This suggests that if quality label schemes are to have more emphasis on environmental criteria than in the past, market value may be enhanced by emphasizing, in labels and advertising, those environmental benefits that are verifiable and in which consumers are most interested. For example, our results showed that farms participating in quality and ecolabelling schemes performed better with respect to plant and animal diversity than did non-participating farms. Biological diversity has growing public appeal, because of desirable landscape implications and a multitude of other environmental benefits, and consumers may be willing to pay some modest price premiums for food products they are convinced result from farming systems that add to biodiversity.

Ecolabelling based on regionally identified quality products represents a potentially attractive market incentive approach to help improve farmers' environmental stewardship. Nevertheless, the future of this approach depends on CAP reforms and discussions within the World Trade Organization (WTO) on the Trade-related Aspects of Intellectual Property Rights (TRIPS) agreement. There is no clear indication whether the EU is working towards a global policy of product quality and origin, which is needed in order to improve the credibility of consumer information. Such a policy would be costly to implement, as it requires a general consensus and the integration of highly interdependent factors – for example, the technical definition of a product, the definition of its typicity and consumer knowledge of these definitions (Barjolle and Sylvander, 2000). Moreover, political conditions for the emergence of such a policy are not yet in place, due to important pressure on the WTO coming from the 'new' world, lead by countries like Australia and the US, and from Latin America, There is a clear distinction between the 'old' and the 'new' world's views regarding quality product labelling. While the 'old' world is defending the recognition of the commercial value of labels, which seek to link products of quality to their geographical origin, the 'new' world tends to condemn such labels as simply another trade barrier.

Although ecolabelled food products can command price premiums, as evidenced especially by organic crop and animal products in many countries, it will be difficult to create and sustain substantial price premiums based on environmental benefits for products mass marketed (Giraud, 2002). Since a large portion of food purchases are made in supermarkets, market signals alone are unlikely to be sufficient to induce socially efficient levels of environmental quality on the agricultural land masses of European and north American countries. Stewardship payments to farmers under national agrienvironmental programmes, together with increased regulatory powers, also will be necessary to achieve some of the multifunctionality expectations now being placed on agriculture in industrialized countries.

Notes

1 See Bertramsen et al (2002) for a brief comparison of 'quality' and 'ecolabelling' schemes in France and the US.
2 The AB belongs to the SOQ category.
3 The CCP correspond to a specific quality CDC, but it can be considered as a certified label only if it is associated with the European 'Indication Geographique Protegee' (IGP) label. This latter certifies an origin quality. Therefore, we classify the CCP among what we call the CDC labels.
4 For more complete and detailed results of the empirical analyses, see Bertramsen (2002).
5 All references to significant differences, henceforth, refer to the 5% level.

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19

The Growth of Urban Agriculture

Nelso Companioni, Yanet Ojeda Hernández, Egidio Páez and Catherine Murphy

In recent years a strong urban agriculture movement has developed in Cuban cities and suburbs.[1] The goal of this movement is to maximize the production of diverse, fresh and safe crops from every patch of previously unused urban land. This urban production is based on three principles: organic methods, which do not contaminate the environment; the rational use of local resources; and the direct marketing of produce to consumers. Thus our urban agriculture fits the concept of sustainability, which in this context means the abundant use of organic matter and biological pest controls, and adherence to the principle of local inputs. The local sale of produce has played a significant role in meeting local food requirements (Companioni et al, 1997).

Urban agriculture has characteristics that differentiate it from conventional agriculture and large-scale production systems, such as the diversity of production and the many people who participate. This gives a special aspect to extension work, where new management models and work styles must be developed to achieve sustainable production levels in each neighbourhood and region.

Urban agriculture is participatory, not only in the sense of the broad base of involvement, but also in demanding diverse responses to the heterogeneity of local conditions, requiring a variety of techniques to create the best possible conditions for production. Because of its geographical location and intended market, this movement must be low-input, use no toxic pesticides, make efficient use of water, and carefully manage soil fertility and the cultivation of its crops and animals. Urban agriculture has received and receives special attention from the highest levels of the Ministry of Agriculture and other government officials.

Reprinted from The growth of urban agriculture by Companioni N, Hernández Y O, Páez E and Murphy C. 2002. In *Sustainable Agriculture and Resistance*, Funes F, García L, Bourque M, Pérez N and Rosset P (eds), 2002. Food First Books, 398 60th Street, Oakland, CA 94618, USA.

Urban Agriculture Yesterday and Today

During the first half of the century, urban agriculture existed on a small scale, involving a few people, and was aimed at the production of a few plant species (mainly leafy vegetables), the rearing of domestic animals in backyards and provisioning of foods for families.

Beginning in the 1960s, high-tech horticultural production techniques were introduced, based on complex technology and crop management systems with a heavy use of chemical products, as are found in hydroponics and 'zeoponics' (production in zeolite susbtrate). The high degree of specialization in these production systems and the development of large enterprises for producing vegetables and other crops during the 1970s and 1980s monopolized the vegetable market, relegating small-scale producers to a second tier (Companioni et al, 1996a).

Like many other countries, Cuba after the Revolution opted to be in the vanguard of the 'Green Revolution', which involved the industrialization of agriculture and the adoption of practices aimed at producing sufficient food for the country. After the Earth Summit in Río, Cuba moved with the world community towards a new emphasis on a more natural agricultural system, through which food quality, the nutrition of the population and natural resources would benefit. Urban agriculture re-emerged recently in this new context for several reasons: the economic difficulties of the 1990s; the low quality of vegetables on the market; shortages of traditional spices and seasonings; and the under-exploited production potential of cities. With a renewed emphasis on urban farming, relatively high levels of production in small areas were made possible by paying close attention to existing local resources and the potential for selling goods locally.

The simplicity of this form of production, and the increase in yields while still improving the technology, allowed for the rapid development of the popular movement in urban agriculture. This new sector has created 160,000 jobs, taken by people of various occupations and backgrounds, including workers, masons, mechanics, housewives, retired people and professionals (López, 2000).

Employing a large number of people in urban agriculture is one of the greatest social impacts of this movement. Driving these changes was the potential for increased income generated by selling produce from urban gardens; (Figure 19.1) this attracted the attention not only of workers, but also professionals from diverse backgrounds, who received state supports in the form of land, credit, services and/or inputs. This new agricultural labour force has brought dynamism and innovation to every municipality.

In each territorial unit, services for urban agriculture are grouped together in what we call a Municipal Urban Farm Enterprise. This administrative unit helps coordinate all urban agricultural activities in the municipality in a variety of ways. It is the source for extension and technical assistance, helps link urban farmers and gardeners with each other, and builds links with research, educational and service centres (Ojeda, 1999). Each Municipal Urban Farm also has the responsibility of organizing production and determining the appropriateness of different technologies for each of

Figure 19.1 *Urban agriculture: public sales outlet, Havana*

its subunits, taking into account local resources, inputs and the potential of the land. Intense technical training for producers has played a decisive role in the achievements attained so far.

Premises of Urban Agriculture

Several basic premises explain the strong potential of urban agriculture:

- Urban centres have the highest demand for those foodstuffs which are easily perishable when transported. Thus there is a basic logic to the notion that perishable foods should be produced as near as possible to the consumer.
- Vegetables, fruits, flowers, spices and intensive animal production all require a large labour force, which is available in towns and cities. In Cuba, 75 per cent of the population is urban, most of which came originally from rural areas; thus, many urban dwellers have empirical knowledge about crop management and livestock production.
- The growth and spread of cities invariably creates many empty spaces in peripherial areas, which often become trash-dumps that are sources of disease vectors, are a danger to human health and despoil the urban environment. Using such areas for food production has eliminated these dangers and has made Cuba's cities healthier and more beautiful.

Basic Principles

Planning for urban agriculture in Cuba is guided by a set of basic principles defining its objectives and organization. Among them are the following:

- uniform distribution throughout the country;
- logical correspondence between production and the number of dwellers of each region;
- crop–animal integration with maximum use of synergies to boost the production of each;
- intensive use of organic matter to boost and preserve soil fertility, and biological pest controls;
- use of each patch of available land to produce food, guaranteeing intensive production and high yields of crops and animals;
- multidisciplinary integration and the intense application of science and technology;
- a fresh supply of good quality products, offered directly to the population, guaranteeing a balanced production of not less than 300g of vegetables daily per capita and an adequate variety of animal protein sources;
- maximum use of the potential to produce food, such as the labour force available and the recycling of wastes and by-products for plant and animal nutrition.

Organizational Structure of Urban Agriculture in Cuba

In Cuba today there is an urban agriculture structure in all cities and towns, thanks to the impact and rapid development of this popular form of food production and to the degree of urbanization of the Cuban population (see Table 19.1).

The National Urban Agriculture Group – composed of specialists and government officials from different scientific and government institutions, and urban farmers – regulates and directs this effort, exercising its influence at different levels all to way to the grassroots through provincial and municipal groups. Regional and local groups are responsible for the organization, development and regulation of urban agriculture in their zone, and the coordination between all entities and persons related to production, processing and distribution of food within the boundaries of each territory and province.

Within each Popular Council (local government at the neighbourhood level), a representative or agricultural delegate coordinates urban agriculture. Likewise, many activities related to urban agriculture – such as veterinary medicine, plant protection and biopesticide production – are represented at the Popular Council. Different areas of responsibility are coordinated through the Popular Councils, which take into consideration the unique characteristics of local systems of production and

Table 19.1 *Urbanization in Cuban province*

Province	*% urban*
Pinar del Rio	63.9
Havana	78.4
City of Havana	100.0
Matanzas	80.3
Villa Clara	77.5
Cienfuegos	80.7
Sancti Spíritus	69.7
Ciego de Ávila	74.6
Camagüey	75.0
Las Tunas	58.8
Holguín	59.0
Granma	57.6
Santiago de Cuba	70.2
Guantánamo	59.6

oversee technical and service units such as the veterinary clinic, farmers' shop, nurseries, laboratories for the production of biological products and others.

Within a municipality, the coordinating activities of the Popular Councils are carried out through the Municipal Urban Farm, which in addition to its coordinating role, has the infrastructure necessary to carry out technical and service activities, with the capability to gather together scientific and technical resources and farmers from different productive areas and related institutions within its territory.

Twenty-six administrative sub-programmes attend to urban agriculture. These are tied to specific topics such as vegetable production, medicinal plants, herbs, grains, fruits and rearing of animals (hens, rabbits, sheep, goats, pigs, bees and fish), all of which can be found throughout the country (Table 19.2).

Vegetables and fresh herbs (organoponics, intensive vegetable gardens, small plots and backyards)

This was the first urban agriculture activity carried out and hence is the most developed. The goal for this type of urban agriculture has been set at producing 30 million quintals[2] (1,380,000 metric tonnes) of fresh vegetables per year, with yields above 20kg/m^2 per year in organoponics (raised beds filled with organic matter), 10kg/m^2 per year in intensive vegetable gardens and 10kg/m^2 per year in small plots and backyards. The goal for the end of 2000 was to have at least 5m^2 per inhabitant dedicated to these types of production, making a substantial contribution to the national goal for all vegetable production of 300g of fresh vegetables daily per capita.

Table 19.2 *Current sub-programmes of Cuban urban agriculture*

1. Soil management and conservation	14. Oilseed crops
2. Organic matter	15. Beans
3. Seeds	16. Animal feeds
4. Irrigation and drainage	17. Apiculture
5. Vegetables and fresh herbs	18. Poultry
6. Medicinal plants and dried herbs	19. Rabbit breeding
7. Ornamental plants and flowers	20. Sheep and goats
8. Fruit trees	21. Swine
9. Shade houses	22. Cows
10. Small-scale 'popular' rice production	23. Aquaculture
11. Trees, coffee, and cocoa	24. Marketing
12. Small-scale 'popular' plantain production	25. Small-scale agro-industry
13. Tropical roots and tubers	26. Science, technology, training, and environmental issues

Source: GNAU, 2000

The heterogeneity of Cuba and the diversity of possible ways to grow vegetables have combined to generate distinct production systems. The most common are the following:

Organoponics and intensive vegetable gardening

These have been the most important methods over the past years and have gone a long way toward helping us rediscover our horticultural traditions. These systems are an example of how scientists and gardeners can work together to develop new production methods (MINAG, 2000). The main difference between these two systems of production lies in the fact that organoponics are generally located in areas with infertile soils or with production constraints. For example, organoponics can be built on artificial surfaces, on which containers are placed and filled with a mixture of organic matter substrate and soil, in which to grow the crops. The intensive vegetable garden is developed on parcels of relatively good soil, without using raised beds, though organic matter is applied directly during preparation for planting (Peña, 1995, 1998). (Figure 19.2.)

Small plots, patios and popular gardens

In this popular form of production, as a rule, the area cultivated is very small and is determined by how much useful or arable space exists between buildings, between houses and streets, or in a patio or a state-owned urban space that can be converted to gardens. In general, the small plots, patios and popular gardens situated in suburban areas are larger than those in the city centres. This type of production now makes significant contributions to household and regional food

Figure 19.2 *Organoponic intensive farming at the 'Gilberto León' Cooperative*

supplies. At this point there are 104,087 parcels and patios under production, covering an area of 3595 hectares, which produce more than organoponics and intensive gardens combined. This type of land use has several positive effects. The small plots, patios and popular gardens have made it possible to feed the urban population; have promoted the development of an urban culture favourable to agriculture; have eliminated the abandoned spaces which in the past may have been breeding grounds for disease vectors and rodents; and have provided socially useful and productive employment opportunities (Ojeda, 1997).

Self-provisioning at factories, offices and businesses

The concentration of industrial production and of innumerable educational, health and service facilities in the main population centres demands the operation of hundreds of workers' cafeterias, whose food supply requires large quantities of diverse agricultural products. A considerable number of workplaces have organized agricultural production in areas bordering, or close to, their facilities. This helps to meet the cafeterias' demand for food without reducing the food resources available to others in the neighbourhood. The magnitude of this form of production has reached a level such that it must be considered a separate form of urban agriculture, particularly because of the differences between these self-provisioning farms and others. In the country's capital alone, there are more than 300 such farms in production. They total an area of 5368 hectares, on which large quantities of vegetables, root crops, grains and fruits, as well as meat, milk, fish, eggs and herbs are produced.

Suburban farms

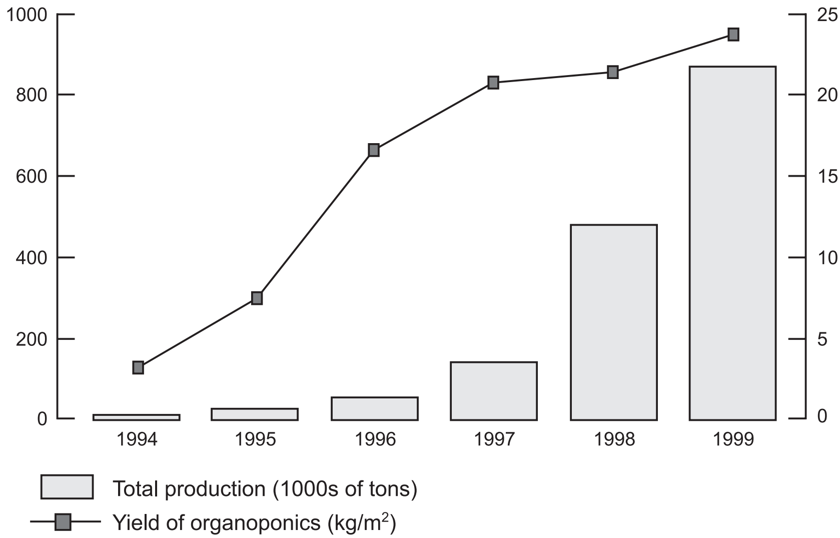
On the edge or outer ring of Cuban cities we find many integrated suburban farms. They grow from the urbanism movement, are considered part of the urban environment and are a key feature in planning for urban growth and development. Although they could never meet all the food needs of the urban population, they are larger than, and have a higher degree of integration among their sub-components than do the small plots and intensive gardens in the interior of the cities. Typically they cover between 2 and 15 hectares. The type of production found on a suburban farm will be strongly influenced by the surrounding population. We can see this from the point of view of infrastructure, recycling of waste products, the crops grown and animals raised, how the products are marketed, etc. This form of agricultural production is characterized by intensive cultivation, efficiency of water use and the maximum reduction of agrotoxins. Suburban farms have reached an important level in the past few years, particularly in the cities of Havana, Santa Clara, Sancti Spíritus, Camagüey and Santiago de Cuba. In the city of Havana, 2000 small private farms and 285 state farms are under production; together these cover an area of 7718 hectares and are highly productive.

Shaded cultivation and apartment-style production

These systems are in their initial phases of development. Covered or shaded production utilizes mesh tents or 'shade houses' of Spanish, Israeli or Cuban design for growing crops and germinating seedlings. Work is underway to develop a complete technology appropriate for Cuban conditions, allowing for the year-round cultivation of horticultural crops, especially during the hottest months when the sun is at its most intense. Apartment-style agriculture is very diverse. It includes a range of practices, including cultivation with diverse soil substrates and nutrient solutions, mini-planting beds, small containers, balconies, roofs, etc., with minimal use of soil. This type of production has its own unique technologies and forms of organization (Carrión, 1996).

Results of the vegetable sub-programme

In recent years this programme has experienced sustainable growth, both in production levels and in the yields obtained (see Figure 19.3). During 1999 vegetable production in organoponics and intensive gardens provided the population with 215g/day per person of fresh horticultural crops (MINAG, 1999), which represents a little more than half of the goals set (see Table 19.3). The most success has been achieved in Cienfuegos, Ciego de Ávila, Sancti Spíritus and Havana. This programme has been the laboratory for testing, confirming and consolidating the principles, objectives and overall perspectives for urban agriculture in Cuba.



Source: MINAG, 1994–1999

Figure 19.3 *Vegetable production from organoponics and intensive vegetable gardens*

Table 19.3 *National vegetable production from organoponics and intensive gardens, 1999*

Province	*Population*	*Area (ha)*	*Production*	*g/day/Person*
Pinardel Río	726,929	602	73.0	274
Havana	689,364	712	88.9	351
City of Havana	2,197,706	462	70.2	88
Matanzas	649,994	382	59.2	249
Villa Clara	830,085	504	65.7	216
Cienfuegos	389,541	402	63.3	442
Sancti Spíritus	456,294	457	60.9	368
Ciego de Ávila	400,720	473	58.8	399
Camagüey	778,772	312	76.6	269
Las Tunas	521,793	314	36.9	193
Holguín	1,018,899	663	58.3	153
Granma	823,481	366	56.1	186
Santiago de Cuba	1,022,105	398	47.9	128
Guantánamo	509,210	162	55.6	299
Isle of Youth	78,259	31	4.6	162
Total	11,093,152	6213	876.0	215

Small-scale 'popular' rice production

This sub-programme has made significant advances in the past three years. Small-scale rice production is growing in all of the country's provinces, and the use of local resources in crop management has generated rice yields above 5tons/ha in many units, a higher level than that which is achieved on state farms.

Medicinal plants and dried herbs

Like the previous programme, this is a recent one within urban agriculture. Herbs and medicinal plants are grown in organoponics and intensive vegetable gardens; yet they have their own programme, which means their production is taken into account in regional planning according to local needs. In some cases, a portion of the production is sold via the Ministry of Public Health for processing into 'green' medicines, which are distributed through the network of public pharmacies. The rest is sold fresh or dry for domestic consumption. Dried herbs are destined for Cuban kitchens; high levels of production make drying essential. Consumption of dried seasonings in Cuba has reached an annual per capita level of 120g. An intensive educational and promotional campaign has been carried out to promote knowledge of their preservation, processing and home use, through publications and radio and TV programmes (Figueroa and Lama, 1997, 1998, 1999).

Ornamental plants and flowers

This is the least advanced sub-programme in the majority of the provinces. There are only a few units dedicated specifically to flower production. This programme has grown in areas around Havana and also others such as Camagüey and Ciego de Ávila. The initial goal is to produce five dozen flowers per capita per year. (Figure 19.4.)

Fruit trees

Despite being a recent addition to the urban agriculture movement, the planting, care and uses of a variety of fruit trees along urban perimeters has long been a tradition in Cuba. This sub-programme has demonstrated a high productive potential, especially in mangoes, avocados and citrus. Current plans contemplate a broad programme of nurseries and grafting in future years in order to accelerate urban fruit production.

Poultry

This sub-programme, specializing in hens and ducks, is the most advanced of the animal production programmes in urban agriculture. Producers are assigned ten females and one male of the semi-rustic local chicken breed. This breed has been

Figure 19.4 *Ornamental plant nursery at the Alamar UBPC in Havana*

produced by crossing a locally adapted Creole hen with a more productive line of hen, such as a Rhode Island Red. From this cross, birds were obtained that are characterized by their resistance to environmental adversity and high productivity of meat and eggs. During their adult stages, this hen, with good feeding (109g/bird/day), will lay eggs year-round with an average annual production of 200 eggs/bird.

A certain amount of progress has been reached with rearing ducks, as it is the domesticated bird with the fastest growth rate. In just seven to eight weeks, ducks can reach between 2.8 and 3.2kg (live weight), converting close to 3kg of feed for each kg of weight gained. Ducks are also less sensitive to environmental stress and food quality, and more resistant to some infectious diseases that are common in birds. In addition to chickens and ducks, geese, turkeys and guinea hens are also produced on a small scale (Companioni et al, 1996b).

Swine

This sub-programme has special features because rearing pigs within city boundaries requires strict sanitary control measures and vaccination. This programme is focused in suburban areas, under the following requirements defined by the Institute of Veterinary Medicine (IMV):

- adequate food supply;
- sufficient water supply for drinking and hygiene;
- confinement;

- a residue pit or biogas digester;
- a cement or tile floor and a roof for protection from weather.

To begin rearing pigs, the prospective producer must sign agreements with the swine production group and the Territorial Technical Service for Swine Production. Through these agreements the producer purchases 12–20kg piglets at a reduced price, as well as part of the necessary feed for fattening. After four to five months, when the pig reaches 90kg or more, the contracted quantity of meat agreed upon by the producer is purchased by the state at the official price and the surplus is sold at higher prices.

If the new pig farmer can produce or find his own pig feed, he need only buy a vitamin and mineral supplement for his animals. To fatten 40 animals on a 140-day cycle, and to finish 100 animals in a year at an average weight of 90kg, it would be necessary to plant four hectares of soybeans, seven hectares of sunflowers and six hectares of sugarcane.

Organic matter

Among the working guidelines for urban agriculture is 'to systematically apply organic matter by using all available local alternatives, and to systematically develop local programs to assure adequate supplies of organic matter'. In view of the importance of this activity, and to realize its potential, a sub-programme was created in charge of organization, promotion and development of organic matter sources, and to assure their collection, processing, conservation and distribution (GNAU, 2000). The National Urban Agriculture Group (GNAU) coordinates these activities, supported by the Organic Fertilizers Reference Center, located at the National Institute for Fundamental Research on Tropical Agriculture (INIFAT) in the City of Havana, as well as by provincial and municipal organic fertilizer centres. This structure extends to the grassroots with centres organized by each Popular Council which receive technical assistance from a Technical Operations Group made up of specialists and farmers from different organizations and institutions. Territorial Organic Fertilizers Centers are responsible for organizing and advising the activities in their territory, geared toward the largest possible proliferation of small production units located at the sources of organic matter or at agricultural production units, to get this important input directly to the farmer or gardener. This activity is characterized by a great use of animal manures and sugarcane filter cake mud (*cachaza*), while the processing of urban agricultural wastes to turn them into organic fertilizers is still insufficient.

Seeds

This sub-programme is aimed at regional self-sufficiency of seed production and distribution, which is critical to the success of urban agriculture and without which production would not be stable or sustainable, because it is essential to have the right seed at the appropriate time for sowing. A network of provincial seed farms has been created, whose job it is to keep the supply of seeds flowing. For seeds that are easily produced by farmers and gardeners, such as cucumber and cowpea, the goal of this programme is to make production units self-sufficient for such crops. This has now been achieved in all urban farms.

Animal feed

The jump in small-scale animal rearing cannot be maintained by solely recycling agricultural waste products as feed. To maximize production of animal protein per unit area, a programme was created to supplement the use of all household scraps and crop residues with the production of feeds on urban farms. Typically these feeds consist of grains, tubers, roots and sugarcane. Despite some progress, most units are still not self-sufficient in terms of animal feed.

Science, technology and training

Training of urban farmers is critical to perfecting the production technologies being employed. In the training sub-programme we focus on practical training, which takes place right in the garden plot, raised beds or animal rearing pens. We have built an extension system, which counts on the participation of its own extension agents, plus research centres, the most experienced farmers and gardeners, and other individuals and institutions related to urban agriculture. Extension is at all times tailored to local conditions and needs, providing farmers with the latest theoretical and practical information.

Other sub-programmes

The remaining programmes are all of recent origin. These include the sub-programmes on sheep and goats, bees, aquaculture, small-scale 'popular' plantain production, trees, coffee and cocoa; tropical roots and tubers; oil seeds; irrigation; small-scale agroindustry; and land use. In most regions these programmes are still in their formative stages, some more advanced than others (e.g. rabbit rearing in the western provinces of the country).

Key Issues in the Development of Urban Agriculture in Cuba

As urban agriculture has grown in Cuba, it has become apparent that there are several key factors that must be borne in mind.

Conservation and management of soil fertility

The productive potential of land available for food production is directly correlated with soil fertility. Although there are many factors that are important in fertility conservation, some require greater attention than others under actual field conditions. Central among these is the control of erosion – maintaining the structure and the physical condition of the soil. The intensity of rainfall in Cuba leads to the rapid leaching of soil nutrients and organic matter, and causes physical damage to soil structure and planting beds. It has proven essential to use a variety of agronomic techniques to protect soils from the effects of erosion. The periodic application of organic matter to soils, planting beds and containers is also indispensable, as nutrients lost or removed by the previous harvest must be returned or recycled, building the fertility necessary for future sowings (Peña, 1995). Finally, appropriate crop rotations and pest management systems adapted to local conditions have been essential.

Integrated pest and disease management

Pest and disease management is based mainly on cultural techniques and biological pesticides. The former rely principally on site selection and planting dates, crop varieties resistant to pests and diseases, adequate soil management, the elimination of alternate hosts of pests and diseases, crop rotations, elimination of infected plants, and thinning and pruning. During the spring and summer months when temperatures are at their hottest, seedling production is carried out in shade-houses, and the technique is employed of leaving clods of earth on the roots of the seedlings to be transplanted. INIFAT has developed totally organic seedling technology guaranteeing high-quality transplants with high yield potential, based on the local resources available in each area. This technique has reduced pest and disease problems due to the high level of vigour displayed by the transplants. The use of biopesticides and other biological pest controls is still being perfected, both in terms of guaranteeing an adequate and opportune supply, as well as with regard to application techniques. *Bacillus thuringiensis* and *Beauveria bassiana* have entered common use since the development and spread of artisanal production at the Centers for the Production of Entomophages and Entomopathogens (CREEs), and they are used against a variety of pests. *Trichoderma* spp. is used for the control of soil diseases. The introduction of new technologies such as neem (*Azadirachta indica*) extracts, and their artisanal and semi-industrial production, as well as of new bio-fungicides with demonstrated effectiveness, are critical for urban agriculture. Overall, food production in the cities is characterized by low pest and disease incidence, thanks especially to small plot sizes and the generous application of organic matter to the soil.

Crop–livestock integration

The nature of food production in cities pushes us towards high levels of production per unit area, facilitated by high levels of agrobiodiversity. The highest levels of productivity in organic farming are obtained when crop and livestock production are linked and fully integrated, a task which compels researchers, farmers and extensionists to work in the closest possible degree of collaboration. Already over half of the urban farms have effective linkages between crop and livestock production.

Urban Agriculture and Sustainability

The organic farming practices used in urban agriculture do not in and of themselves guarantee sustainability. To achieve sustainability all aspects of production must be rationalized and integrated, so that each component complements each other component, in such a way that each action leads to a better outcome at a lower cost.

The best example of this is found in the use of harvest residues and unmarketable portions as animal feed, in turn using the animals' manure to fertilize the crops. We have developed a set of indicators of sustainability to use in perfecting urban production systems. Among these indicators are the following:

- amount of organic matter collected, processed and applied;
- use of soil conservation methods to prevent erosion;
- degree to which seeds and starter-animals (i.e. chicks) are produced locally;
- degree to which varieties and breeds are adapted to local conditions;
- degree of crop–livestock integration;
- local water availability and soil moisture;
- efficiency of water use;
- amount of food produced/hectare per year;
- amount of food produced per capita;
- use of integrated pest and disease management systems;
- net profitability of production;
- degree of participation of farmers in training courses and extension activities.

By keeping track of these indicators we can monitor the development of urban agriculture. As the indicators improve over time, the sustainability of urban agriculture will be consolidated.

Conclusion

Over past few years the urban agriculture movement in Cuba has clearly demonstrated the food producing potential of cities. Today it is an important source of food for our urban populations. This has been made possible by the decisive effort put forth by urban farmers, and by the support given them by the government to carry out their tasks. The high-level of organization that has been achieved should make it possible to successfully implement the ambitious plans that are currently on the drawing board. We expect that in the near future urban agriculture will satisfy a high percentage of the food needs of our population.

Notes

1 Editor's note to the English edition: At the time of the final editing of this volume, an estimated 90 per cent of the fresh produce consumed in Havana is being produced in and around the city (Egidio Páez, pers. comm.).

2 One quintal equals 100 pounds.

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20

The Quest for Ecological Modernization: Re-Spacing Rural Development and Agrifood Studies

Terry Marsden

Over recent years the sub-disciplines of rural sociology, development studies and the newly emerging social science of the environment have been attempting to address many of the same types of theoretical and empirical questions albeit from different starting points. The rural sociology of advanced economies has for a long time now drawn very productively from the field of development studies, even if both have remained quite distinct sub-disciplines with their own communities of interest and professional publication outlets (see Long, 2000). Similarly, the growth of work on the sociology of the environment, particularly in the European and North American context, has attempted to very much set its own broad agenda, but has done so in ways which have overlapped with the theoretical agenda of the more traditional rural sociology. Buttel (1996) and Frouws and Mol (1999) have traced the ways in which rural sociology acted as a 'formative' sub-discipline to the wider environmental sociology. And they question the extent to which these formative roles are gradually being reversed. The former's increasing ecumenical concern for aspects of rural nature, as almost a 'last refuge' in the process of urban and industrially based modernization, has meant that it has been the originator of significant theoretical and conceptual impulses into the wider and growing debates which have encapsulated environmental social science. While the latter, it might be argued, has taken on a more industrial and urban basis – addressing questions of ecological modernization, for instance, – it has also needed to refer to key authors in the older, parental disciplines of rural and development sociology (see Murphy, 2000). Indeed, all three sub-areas witness the creative engagement of several key authors who have their origins in rural sociology and anthropology. None of these authors would just regard themselves as rural sociologists per se; rather they are contributing to wider sociological and geographical debates concerning nature, space

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and environmental policy (see, for instance, the contributions to *The Environmental Sociology Handbook*, edited by Redclift and Woodgate, 1998; and Buttel, 2000).

Some may suggest that these developments represent something of a chaotic and disparate set of conditions which tend to diminish, rather than enhance, the true innovative character of the rural sociology of advanced economies. This paper will aim to demonstrate, alternatively, how a wider theoretical and conceptual landscape, based around environmental social theory, can help to assist contemporary rural sociology in progressing its agenda (Milbourne, 2003). Of particular relevance here is an assessment of rural sociology by Buttel (2001), where he makes the point that in the past decades work on aspects of regulation and globalization, for instance, has tended to be quite the reverse of the earlier theoretical developments of the 1970s and 1980s (what was then termed the 'new rural sociology'). He argues for more theoretical innovation to be undertaken. While the past decade or so has demonstrated quite a flurry of rich empirically engaged work (on areas of globalization, for example), actual theoretical development has reached, he argues, something of a hiatus; with various 'schools' tending to adopt a position along the actor-oriented–political-economy axis. At the very least we may have witnessed a period of more theoretical pluralism; which, in turn, may be perceived by some as reducing the power of meta-theory. Moreover, as Buttel also alludes, this can lead to the rather random/chaotic choice of micro-empirical case studies; with the suggestion that this can begin to lose sight of 'the big picture'. A key question here then is how can a more meta-theoretical agenda be established?

Ecological Modernization and More Sustainable Rural Development: Towards New Rural Eco-realities

However critical one might be about arguments associated with the rhetoric of sustainability, it is also the case that writers have pointed to the development, albeit fledgling in some cases, of a more ecologically modernizing agenda built upon a diverse theoretical base (see Buttel, 2000; Gibbs, 2000; Mol, 2000; Murphy, 2000). This is centrally associated with a European perspective on the development of clean industrial technologies, and the ways in which environmental coalitions and movements begin to affect reluctant state agencies. So far, they have only partially been applied to the rural sphere (see Frouws and Mol, 1999; Buttel, 2000), having been confined to the focus upon 'win–win' solutions in the business context (see Andersen and Massa, 2000). However, the degree to which we might be entering a new phase of modernization which would be much more autonomously 'ecological' is becoming a central theme in rural and agrofood studies (see Goodman, 1999, for instance), and the rural domain is becoming a central field for exploring the role and meaning of social nature debates (Milbourne, 2003). This could represent a new surge of creative and critical connections between environmental social theory as represented by the broad church of ecological modernization, on the one hand, and a more open and pluralistically engaged rural sociology on the other. It is to this exploration that this paper wishes to contribute.

Taking Buttel's theoretical challenge seriously, and at the same time as the arrival of more effective debates about a new (ecologically) modernizing process, it is necessary to address a central theoretical question. This in macro terms is: *to what extent are we seeing the arrival of a more autonomous ecologically modernizing process operating in advanced societies, and as part of this, through rural development trends specifically? Second, if we believe that this is a viable question, then what conceptual development and empirical realities does it suggest with respect to the rural sphere?* Taking some empirical and theoretical avenues in the three resource areas of agricultural restructuring, food supply chains and forestry, this paper adopts a positive view with regard to the first meta-question. It then attempts to demonstrate, through the definition of some conceptual parameters, how scholars might address the challenge this creates in tackling the second question.[1] With specific reference to these rural resource spheres it is suggested that we are witnessing the development of an ecological modernization process which is significantly different and autonomous in its character from the earlier industrial, 20th century modernization process. As Frouws and Mol theoretically delineate (1999, p271):

> The ecological modernization theory analyses possibilities for a process of 're-embedding' economic practices-in view of their ecological dimension-within the institutions of modernity. This modern 're-embedding' process should result in the institutionalization of 'ecology' in the social practices and institutions of production and consumption. The institutionalization of ecological interests in production and consumption processes, and thus the redirection of these basically economic practices into more ecologically sound ones, involves an 'emancipation' or differentiation of ecology. The differentiation of an ecological rationality and an ecological sphere, both becoming relatively independent from their economic counterparts, is the logical next step.

This process is analytically challenging in the sense that it is necessary at the same time to differentiate between ecological 'spheres' – that is, making analytical space for considering relatively autonomous ecological spheres so as to study how ecological actions and practices are becoming steadily institutionalized in the central institutions of modernity – but doing so without completely labelling these as distinct areas in society, that can simply be empirically identified. *The process of emancipation from the strictly economic sphere, and the gradual re-embedding of ecology in the institutions of economy, is a central aspect of ecological modernization, creating the spaces for an ecological as well as economic rationality*. This socio-ecological postulate requires detailed assessment in terms of its relevance to rural development – and it raises a theoretical potentiality for developing a more robust sustainable rural development paradigm (see Van der Ploeg et al, 2000; Marsden et al, 2003).

We should, of course, also recognize that this does not deny the maintenance of a dominant economic rationality, working as it may do to limit these new ecological, social, economic and political spaces. However, as some ecological theorists propose it does question the longevity of what Buttel (2000) refers to as the more established rational frameworks of the 'treadmill of production' and the 'growth machine' which have by no means completely disappeared. Arguably, however, they are in many places less in their ascendancy and subject to internal and external crisis tendencies (such as food scares, legitimization and ethical concerns, pollution incidents and long-term health problems, and not least the increasing and uneven global regulation of greenhouse gases), as well as deep structural tendencies which are seen as increasingly contradictory. Despite these internalized problems in the governmentality of a strictly economic rationality, it does not seem to reduce the possibility of strong reactive ('backlash') politics from taking ground back from the ecologically modernizing agenda. This is, for instance, one interpretation of the US Bush administration and its arguments against the signing of the Kyoto agreement, and the renewed faith in the domestic exploitation of oil reserves (Watts, 2002). Nevertheless, social-ecological debates and discourses are gaining ground in different guises and through different types of social, political and economic practices. While these may confront the former structural changes, associated with globalization of corporate capital, for instance, they are by no means simply marginal or subject to the marginalization effects of corporate states, firms and their social and political logics. Rather, and from a rural perspective, they may suggest a new centrality for many of the features of rural life that the industrially based modernization process tended to marginalize – for instance, aspects of agroecological development as part of rural development (see Rannikko, 1999; Jokinen, 2000), the development of decentralized and more sustainable rural communities as a central part of settlement hierarchies, and more mobile and information and communication technology-based sharing of experiences in rural and urban areas (Andersen, 2002). Indeed, we might suggest that one central element of ecological modernization is the very redefinition of the spatial and social balances between the more mobile urban and rural living experiences and frameworks; and about the realignment, more specifically, between nature, quality, region and locale, producers and consumers, for a more ecological rural resource base.

Some may see these notions as going too far. Moreover, we have to recognize that there are significant distinguishing features between what Christoff (1996) and Toke (2002) depict as forms of 'weak' and 'strong' ecological modernization; suggesting a caution about both the direction and pace of 'autonomous ecologism'. Nevertheless, we need to analytically explore these modalities between the economic and ecological rationalities, on the one hand, and the uneven development of 'weak' and 'strong' ecological modernization tendencies on the other. In addition, this challenges us to provide ecological modernization with a more robust theoretical basis, one which deepens the political-sociological perspective of ecological modernization such that the way forward would at least include not just:

> empirical debates over the potentials and limits of environmental engineering and industrial ecology, but rather to deepen the links to political-sociological literatures which will suggest new research problems and hypotheses (Buttel, 2000, p64).

We see here then a significant theoretical and empirical challenge both for rural sociology, on the one hand, and the broader field of environmental social science on the other. Both could benefit from at least engaging with the emergence of ecological modernization theory, if only to address the very longevity and resilience of the 20th century 'growth machine' and 'treadmill of production'. More optimistically such a deeper engagement could begin to set the coordinates for mapping Frouws and Mol's more 'deeper' ecologically embedded and conceptually autonomous model of ecological modernization.

Rural development becomes in this context a potentially rich sphere to assess these ecologizing tendencies, and to test the contingencies and frameworks involved in rebuilding a more viable and robust rural development perspective which at least begins to suggest how such ecological modernization notions might be more effectively progressed. Indeed, just as with the industrial mode of modernization (with its reliance upon a particular form of neoclassical economics), a new ecological paradigm also needs a viable, critical and normatively engaging social science. This is particularly the case with ecological modernization given, as we shall see below, the spatially variable and context dependent ways in which it actually expresses itself. What seems clear is that there is a lack of coherence in ecological modernization, one which can be partially or contradictorily adopted by national, regional and local governments; and one which may need particular confluences of strategic and local interests and actors to operate in new and innovative ways.

Looking at the recent rural sociological, and particularly the environmental social science literature over recent years, one begins to see this tendency being reported. One further key question is how far and fast will it travel, and how do we best equip ourselves as scholars to develop a growing relevance in understanding and mediating its required and contested knowledges?

There are some significant questions here. If we are to meet Buttel's theoretical challenge, it would suggest that we have to start looking at these bigger pictures. The 'new rural sociology' and political economy established and developed throughout the 1980s and 1990s was built upon the development of an intense and very effective critique of the late 20th century industrialization/modernization project (particularly as it related to the agrofood complex). We should perhaps now recognize that this challenge has now begun to change, for it is no longer sufficient to just critically examine the problems of such 'ageing regimes'. We need to be reconstructing as well as deconstructing models and frameworks which suggest *how things could work in different and more socio-ecological ways over space and time*. We need to visualize and articulate how actions and cases at one level can build up more broadly into significant and autonomous projects of change.

This paper aims to suggest a series of key concepts and theoretical formulations which could begin to build, not so much upon the diffusion of effort that some might argue we have witnessed, but on some useful integrative themes which could lead to a more robust and theoretically engaging of rural sociology with environmental sociology. In particular, it will be argued that this involves the need to re-problematize space and spatial relations (as socio-natural constructions) in our analyses, and to do so in ways which re-engage with the somewhat traditional sociological concepts of *community, regulation, consumption, exclusion, justice, bureaucratization, professionalization and expertise, associationalism* and *responsibility*. By doing this we can begin also to integrate some of the overdrawn dichotomies and debates between political economy and actor strategies and networks, social constructivism and realism, globalization and localism, economistically determined productionism and culturally confined consumptionism. It is argued that we need more engaging conceptual and theoretical formulations which help and guide us to not only make sense of the 'new ruralities' which confront us, but also to allow more *reconstructivist* as well as *critical interpretive* roles in both rural and environmental social sciences.

Exploring and taking forward ecological modernization debates may, therefore, be one way of meeting this growing need within rural sociology for improved theoretical engagement. As Frouws and Mol (1999, p286) conclude in their analysis of the ecological modernization of Dutch agriculture:

> Environmental sociology seems, in this respect, indeed capable of being a 'formative power' in the development of rural sociology. Its contribution is especially valuable to clarify the all-embracing impact of the environmental question on the technological and institutional reconstruction of agriculture, and to address its social, political and economic implications... This brief exploration also revealed, between the lines, the socio-political contestability and indeterminate outcome of ecological modernization as a political programme for agricultural change in the Netherlands.

Here, the paper outlines six key conceptual areas that are in need of development, which, it can be argued, give some pathways forward on which to continue to build such 'formative power'. These are explored here with reference to recent empirical research undertaken in the food, farming and forestry sectors on a variety of rural development projects.

Key Conceptual Starting Points: Empowering Social Ecologies

Environmental and territorial justice

A key feature of current patterns of rural development concern what seems to be greater amounts of economic and geographical uneven development. This is partly exacerbated by the gradual neoliberal shift, on the part of many nationstates, away from explicitly fostering more convergent, balanced, regional economic development. A key feature of extant rural and environmental arenas comes then in needing to address aspects of both territorial and environmental justice. The adoption of sustainable development goals cannot really be progressed unless they begin to deal with spatial uneven development, and particularly how local and regional conditions are incorporated into the analysis of how those broader and long-term conditions could be improved. A central question to consider is the extent to which scholars engage with the debates and assumptions of territorial and environmental justice. That is, having identified injustices in the uneven risk, distribution and quality of resources in space, how far should we go in formulating ways of reducing or compensating for this unevenness? For instance, it is quite clear from work on forestry and community in South Wales (see Marsden et al, 2003) that any attempts by the UK Forestry Commission[2] to encourage more participation and inclusion in the forested areas is constrained by the quite long history of growing social and spatially based deprivation of the nearby communities, for which the withdrawal of other state services and support structures has played a full part. Similarly, the growing social science research in the areas of food scarcity, and the identification of (both price and quality) 'food deserts' – often themselves hidden enclaves in larger, prosperous cities and regions, see Wrigley (2002) – demonstrates, on the one hand, the acute unevenness of rights to food consumption that the now corporate retailer-led supply chains have reproduced. The question is, however, not simply the issue of the empirical identification of these disparities. It also concerns how an engaging social science of rural development and food formulates alternatives which reduce and combat these. In the rural development field, while many of the grant-aided funding schemes emanating out of the EU still have (at least ostensibly) a strong territorial justice philosophy behind them (e.g. Structures funding, LEADER, Less Favoured Areas, etc.), the emphasis of a social capital and capacity logic governing local and regional allocations systems inevitably means that many rural groups and localities are failing to develop the critical mass to establish and capture such funding benefits.[3]

Hence, we can see here that progressing environmental and territorial justice questions are almost unavoidable in addressing these new developmental trends (see Economic and Social Research Council, 2001). For instance, what are the consequences of the further concentration of resources and economic development? What sort of trade-offs are possible or legitimate? How can injustices be compensated, monetarily and non-monetarily? How can a more multi-level-governance system in the rural development sphere (i.e. combinations of EU, national, regional and local policy platforms) progress a renewed set of regional and local convergence policies? Moreover, what are the social and political effects of persistent territorial injustices: in and through different rural spaces?

Community and association

Much of the social science of the environment literature (see, for instance, Irwin, 2001) and rural social nature debates have tended to so far underplay one of the traditional strengths of rural sociology: community. Somewhat surprising perhaps is that notions of community and association have failed to re-emerge as an important working and active mechanism between the social and the natural (but see Joseph Rowntree Foundation, 2002). Two examples illustrate this from our work on farming and rural development, and from the forestry and community work.

Alternative supply chains and rural development activities are, it seems, built upon new sets of associations and associational capacities of actors to engage in ways which shape both the social and the natural. Associational interfaces (often as emerging and contingent networks and chains) are both informal and highly significant in establishing trust, common understandings, working patterns, and forms of cooperation and co-optation between different actors in the supply chain. These differ from institutional interfaces which include state regulations and the support and services offered by rural economic development agencies (see Long, 2000). And, they are often crucial in generating and facilitating supply chain interfaces at a regional level – a key new spatial platform for the development of agro-food alternatives to take hold (see Renting et al, 2003). However, such interfaces are vulnerable to internal and externally generated disruptions. There is no inevitability that strong and mutually reinforcing associational interfaces will be reproduced over time. Furthermore, where they do not exist, or have broken down, it may take many years to rebuild relationships and working trust relationships to a point where regional or local actors – or actors acting at a distance across a supply chain – can create the conditions necessary to effectively and efficiently meet and relate to consumer demands. In many cases, in what we term 'short supply chains', these new associational competences are formed across the traditionally recognized producer/consumer arena. Indeed, reconnecting associational capacity across this former divide is part of the new sets of innovations that mark out the new modernization projects from the old. Evidence from European case studies suggests that sustaining rural development through the evolution of reconfigured supply chains must be based upon new combinations of both institutional support and associational development. Furthermore, these relationships must be able to adapt to internal and external shocks and pressures over time and space. Here, and again distinctively, there is no one model. A key question then is the degree to which these features will need to become more widespread if real aggregated rural development impacts are to be achieved, and how, if they are not apparent, can they be generated?

In the non-productive sphere of residential forest communities in South Wales, we also see how deep-seated local interpretations and impressions of community, and particularly of the marginalization effects of the State as part of community life, have a critical bearing upon the constructions and shapes of socio-natural relations and practices in that community (see also Rannikko, 1999). In short, the social character and construction of the community – in this case a socially rich place, but marginalized and peripheralized by the State – provides an important social prism through which nature is perceived and used. Hence socio-natural perceptions and practices emerge as an expression of the social construction of the community and, in this case, the particular incision of the state in this construction. In this sense what we can infer from this is that particular types or sets of socio-natural relations and practices cannot be simply 'read-off' from the prevailing sets of '(realist)' social and economic regulatory conditions. Neither, however, as social constructionists may propose, can they just be rendered as varyingly 'co-constructed' within environmentally related practices and social contexts (Irwin, 2001). The residents in the community are not just free agents in their constructions of natural relations. Neither is the forest a neutral natural actant operating in a completely natural setting. Both nature (in this case the forest) and the people are actively engaging in broader socio-political conditions which, in turn help to shape the particular types of socio-natural relations in this type of local context. While such a postulate suggests that there is an inherent partiality about the two earlier approaches. What needs to be added to both conceptions is an empirically embedded understanding of how the natural becomes an active ingredient in the continual process of community construction.

Exclusion and empowerment

While aspects of rural social exclusion have become a vibrant topic of concern, especially amongst rural geographers (see Cloke et al, 2000; Shucksmith, 2000), the emphasis of this work has thus far been largely upon the identification of exclusionary practices in different social, economic, institutional and domestic rural arena. One further and important aspect, however, concerns the ways in which communities, different actors and agencies can become more empowered, and to do so in contexts which are ecologically as well as socially sustainable. In our UK forestry communities we witness a long historical process of disempowerment brought about by both the productivist priorities of the mining and forestry sectors and, in addition, the gradual marginalization of much of the community by labour markets and the state authorities. Here disempowerment is multifaceted, and it is the combination of these *marginalization histories* which provide the backdrop for any change of forestry commission policy in terms of enhancing community and sustainable development. The exclusion-empowerment equations operate differently between and through communities and they provide a key mechanism in establishing the social landscape upon which new, more ecological forms of modernization could take hold. Indeed, they provide a major way in which ecological modernizing principles can in themselves become marginalized and obscured in the face of what are seen to be more short-term employment imperatives.

A further, if separate element of exclusion and empowerment comes in terms of the market and consumer exclusions operating in the conventional food supply system. Here we see two key processes at work which deserve much more attention in progressing a more ecologically modernizing agenda. These concern the exclusionary tendencies based upon price, quality and location encouraged by the corporate retailers in the operation of their food chains (see Competition Commission, 2000). This is generating a major feature of the 'new food polities', with consumer agencies adopting exclusionary arguments as well as food quality arguments in their political articulations with government authorities. The operation of what is called in the trade as 'price flexing' – whereby the big retailers purposely vary their grocery prices in the light of local competitive conditions rather than being related to actual costs – has become widespread in the UK. Even the conservatively written recent

Competition Commission report of the national government concluded that where the big corporate retailers were practising this, it tended to operate against the public interest. Customers tend to pay more at stores that do not face particular competitors than they would do if those competitors were present in the area. In many of the marginalized working class areas of the urban and rural UK, these monopoly retailing arrangements are now commonplace. Hence we see here that there is a real need to link the particular corporate and institutional practices with local empowerment and exclusionary conditions – in space. In many of the debates so far – both academic and public policy – these linkages in space have been at best blurred. Indeed, the spacing of exclusionary practices and their links to corporate strategies has been neglected. It is not so much about the identification of 'food deserts' as understanding the interfaces of corporate strategy and local consumption in their varied spatial contexts. As this example shows, what we witness in many areas are competition practices going in reverse. With major retailers being able to create almost 'monopoly consumption spaces' in which they can raise prices, beyond their relationships with 'true' costs. Keeping other retail competitors out as well as harnessing loyal and recurrent consumers in to their stores becomes a central mechanism *in* the territoriality of exclusive food consumption in the British context.

A third arena of exclusion/empowerment concerns those at the other end of the food supply chain – the primary producers. Despite all the government rhetoric about the need to abide by the laws of fair trading and European competition policy, many farmers and many processors find themselves excluded from the often more lucrative retailer-led food markets. For those that do gain entry, the degree of informal control over their operations severely constrains their 'room for manoeuvre'. In many ways these are the newly created forces of subsumption operating in the retailer-led chains; whereby pricing and conditions can be placed upon producers and processors in ways which are seen to be 'consumer-led', but really emerge from the day-to-day management of these supply chains by the category managers of the retailers. With exclusion or relative empowerment in this regard, therefore, we see also the creative development of social and economic dependencies operating between different sets of actors in the supply chain. Local rural and agricultural spaces are, therefore, no longer controlled at a distance by the corporate input suppliers (i.e. associated with concepts of appropriation, substitution and subsumption of production). Now it is more variably conditioned by the downstream merchant (rather than industrial) retailer elites who engage groups of consumers and governments in their powerful networks. Hence, primary production becomes something of a backwater and 'dirty' activity which needs to be 'cleaned up' by the state and corporate retailers on behalf of the public.

We see here, then, through these examples how exclusion and empowerment strands are a critical integrating mechanism for bringing together the social, economic and institutional construction of power, both in and through rural (as well as urban) spaces. This is cross-cutting both vertically through supply chains and laterally through community/institutional interfaces.

Consumption and production: socially and culturally reconstructing the commodity

While considerably more emphasis has been placed upon understanding the relationships between production and consumption, and particularly the ways in which the very fabric of food fuses both natural and social hybridities, there needs to be more attention given to the ways in which the hybrid social and natural relations surrounding food are governed, empowered and used. While accepting that there has been something of a (somewhat overdrawn) conceptual distinction made between the more political economy-inspired analysis of production and the more culturally inspired consumption studies, there is a clear need to explore how new alliances, relationships and metabolic equations can be brought together in ways which progress the understanding of alternative food networks or chains. Also, we need to know much more about how these both use and travel through space. Our recent European evidence suggests high levels of spatial variability between different rural regions in the setting up and sustenance of alternative supply chains (Renting et al, 2003). These variabilities are particularly affected by the type and degree of institutional support, via, not just the national state, but regional and knowledge and skill-based agencies, and by the highly context-dependent types of associational involvement from a variety of different actors. It is clear that the innovation patterns, the skills bases and the degree to which such initiatives can utilize and exploit the 'territorial worth' of their localities and regions are all critical factors. These factors show that aspects of space, quality convention, nature, and agricultural and food socio-technical practices (the particular ways of cutting, curing, salting and carving of meats, for instance) come together in rural spaces. Moreover, many of these initiatives also reconstruct important new co-locational alliances with specific groups of consumers. Many consumers, for their part, are increasingly searching for 'something else' other than the standardized or indeed mass-produced specialized types of food product. The consumption experience, often involving direct contact with the producer or the seller becomes an important ritualistic consumption practice.

However, what marks these alternative food chains out from the conventional system is by no means their face-to-face nature necessarily. In some of the more maturer quality supply chains we see the development of spatially extended networks, which are selling brands, labels and seriously commodifying their culinary repertoires (e.g. Parmigiano Reggiano Cheese). They are still categorically alternative, however, in that they have done and do re-equate nature, space, socio-technical practices and quality conventions in ways which make it impossible to replicate these outside that network. These then are the new ecologically deepened supply chains, and to describe and understand them requires much more than a recourse to such generalized notions of mutual or reciprocal metabolics. Rather, it requires a concerted effort to understand the theory and practices of the actors – producer, consumers and exchange actors – who mobilize and animate/demarcate such networks (see Verschoor, 1998, for instance). These new food networks are now a common occurrence and in many regions are by no means marginal to the conventional system. In Northern Italy then we see a concentration of quality food networks, while in Germany and The Netherlands, new alliances are more associated with agri-tourism ventures and nature and landscape management. Food, as a culturally hybrid entity, becomes unevenly embedded into the fabric of new rural development practices; and new synergies become developed between food, agricultural practice, consumption practices and associational and institutional arrangements.

Understanding the wealth and worth of these series of micro-social practices and, still more, assessing what in more generalized terms they 'add up to' is a major empirical and theoretical task, for which scholars have only recently embarked. It is clear, however, that the volatilities in the consumption/production relations associated with the conventional systems, will have pervasive effects and interactions upon the competitive spaces that these alternative food supply chains operate in. This is highly contingent, not just upon some vague notions of consumer culture or sovereignty. It is also centrally conditioned by the contested and institutional ways in which the 'consumer interest' is continually constructed – and by whom. Such analytical progress will not rely just upon a realization that nature and society are hybridized in food. The issue is how, where and by which powerful/non-powerful actors? Food as a realm of governance and social and political regulation is not contradicted by more socially constructivist processes. These need to be put together, not least because institutional actors and agencies are part of that constructed and contested process. Somehow, we need to understand how alternative food networks not only get formed, but then get demarcated and maintained as a socio-competitive dynamic. They are not static events.

Corporate responsibility and accountability

The past two decades have witnessed a significant growth in research work on the globalization and regulation of agribusiness and the workings of multinationals (for a review of the commodity systems approach, see Friedland, 2001). This has been a major development of the discipline of rural sociology, and it has emerged as a clear critique of industrial modernization in the agro-food sector. In postulating aspects of ecological modernization, however, we also now need to consider and critically assess how business relationships (with each other, with consumers and with local communities) are changing as a result of a number of significant forces. These include: changes in the regulatory frameworks; the globalization of supply chains and the increasing mobility of capital and knowledge; the application of ICT to radically restructure certain markets, industries and places; changing patterns of consumption and falling consumer trust in existing forms of corporate and government communications; the emergence of civil society groups and global protest movements and a realization that companies may be more vulnerable to pressure for change than entrenched or undemocratic governments; the fragmentation of local communities and constructions of community; the pressure from the investment community in the form of the growing ethical investment movement; and the pressure from insurers who see the reduction of environmental damage and social conflict as an important way for companies to reduce levels of risk.

These reconstituting forces are, in turn, reshaping the relationships between firms, governments and 'communities of interest'. Among the actors there are key constituencies who will help to shape the dynamic and developing relationships both within their actor-spaces and between themselves and other actors. From the point of view of business it is now more essential (albeit to varying spatial and sectoral degrees) that these relationships are constructed and constantly reconstructed in ways that help to ensure its longer-term survival. These can be depicted in Figure 20.1. However, neither the effects on businesses of the processes of change that are identified here will not be even, and nor will be the impacts on the 'communities of interest'. *What is necessary in research terms then is to theoretically and empirically understand the richness, complexity and contestability of business responses to, and the management of, its environment.* In short we need new constructed models of (potentially autonomous) business behaviour and relationships which are embedded in the social, environmental and political contexts which they are attempting to shape.

So far environmental and rural sociologists have tended to avoid these ventures, leaving it to the environmental economists and ethical marketing specialists to engage in the tracing of these new patterns. For instance, such discipline-specific research is pursuing the following lines:

- The inclusion of sustainability and social responsiveness within corporate accounting and reporting practices, and its relationships to the growing ethical

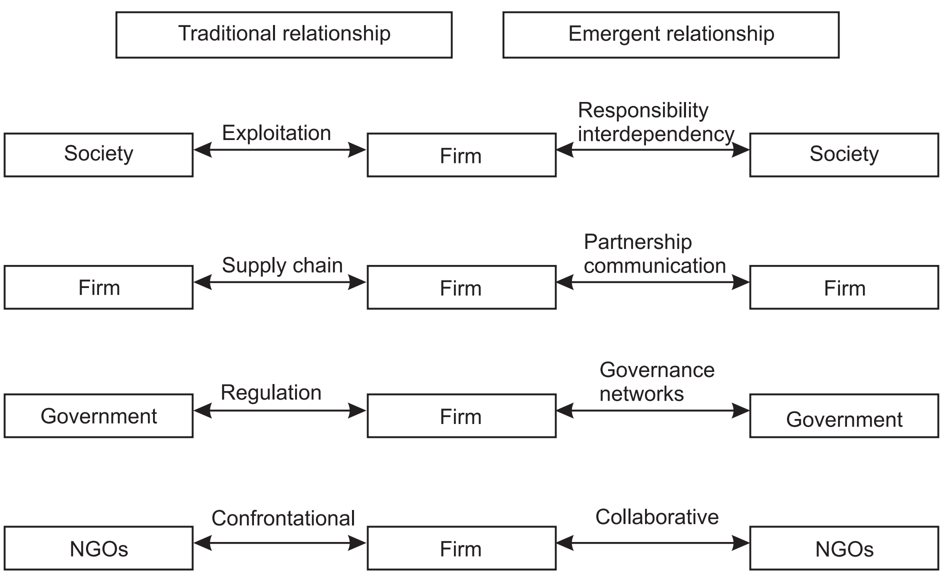

Figure 20.1 *Changing relationships between key actors*

investment industry is typically being researched within the accounting and finance disciplines (e.g. Gray et al, 1995).
- Changing consumer demand for ethically and environmentally acceptable products and the response of companies to demands for such products, new information and new marketing approaches is typically being researched by the marketing and economics disciplines (e.g. Menon and Menon, 1997).
- The evolution of environmental and social regulation and its impact on firms is typically researched within the legal and public policy discipline (e.g. Garrod, 2000).
- The implications of sustainability in terms of industry structure and infrastructure is typically a focus of research in the planning, geography and public policy disciplines (e.g. Ogu, 2000).
- And, the influence of global capital flows and governance standards is primarily researched within the law, finance and international relations disciplines (see Brack, 1995).

Yet, in all these areas environmental social science, and more specifically rural social science, has a potentially important role to play, particularly in understanding how these changing business, government and community relationships are spaced and re-spaced. In the food sector, for instance, the contested competitive spaces between conventional and alternative supply chains is occurring in a broader context of a reduced reliance simply upon legal compliance as a justification and legitimization of actions. In this sense *de jure* regulation is not enough. Also, there is a broadening amongst many firms of the 'stakeholder concept' whereby companies are increasingly having to respond not just to customers and investors, but also those with a physical stake in their actions, including the communities within which they operate and NGOs representing myriad interests (Polonsky, 1995). We see this empirically, for instance in the redefinition of UK Forestry Commission policy and the new sets of relationships developing with government agencies. Moreover, consumer groups and governments have traditionally championed consumer rights in terms of choice, value and safety of products. Yet concerns over the sustainability and social responsiveness of businesses has led to an increased interest among stakeholders about the methods and consequences of production (Peattie, 1999). This is most easily observable within the food industry, where concern is centred on issues relating to production practices – such as the use of chemicals, the use of genetically modified organisms and the constituents of animal feedstuffs, pollution and the destruction of habitats. These trends suggest, at the very least, a set of key research questions:

- How are changing patterns of demand leading to the development of more sustainable and socially responsible strategies, products and technologies?
- What types of new market and institutional structures (e.g. supply loops and networks) will develop in response to product take-back, as businesses are required by legislation and consumer pressure to become even more accountable for the life cycle of their products?

- What opportunities will arise for the restructuring of industries around new business models and types of production systems and technologies?
- How will business-to-business and business-to-consumer relationships change if a service-based economy (i.e. through leasing, take-back and service arrangements) begins to replace the traditional exchange of physical goods?

To begin to answer some of these questions will require the development of new social and regulatory 'designs' around which we can begin to explore the richness and complexity of business/environment relationships. Such an endeavour will need to take us far beyond the much more established and somewhat retrospective 'tracking' of multinational commodity flows. Moreover, we should put aside the rather binary question of whether firms will or will not ecologically modernize. Rather, we should explore both *what* is and *what might be*.

Regulation and bureaucratic professionalization

It is important to recognize that the story of environmentalization in the rural field over the past two decades has been one in which a particular form of Weberian bureaucracy has been increasingly prevalent. We need to recognize both why this has been the case and, conversely, why it is not necessarily the only model in town (see Marsden et al, 2001). I have, in the context of the agricultural and food sector in Europe (post-BSE) termed this more specifically the *hygienic mode of regulation*. As the industrial mode of food supply has become even more crisis-ridden, the state has attempted to largely 'correct' this by setting up highly professionalized and bureaucratized forms of environmental safeguards and instruments. This has also been conducted in 'the interests of the consumer', as a way of governments seeking to protect their interests at the same time as allowing corporate industry the ability to exploit new markets. The growth of a profound regulatory burden, as a response to the crisis in the industrial mode of agro-food, tends therefore only to strengthen the economic and political power of established agroindustrial interests (including the large retailers and manufacturers). Both private and public forms of regulation are used to 'clean-up' the industrial system in the ostensible 'public interest'. Such *schematization* holds the added consequence of further constraining the real potential of integrated agricultural development as well as providing new regulatory barriers to market entry for many smaller producers and processors. For consumers, it allows the disconnections and distanciations between production and consumption to conveniently continue: with an encouragement that 'safety' comes before sustainability. A growth industry for many environmental scholars has been found in the evaluation of such *hygienic schemata*.

These processes have tended to break, or at least 'fracture' the environmental and rural development question into specific boxes, projects and schemes; making it more difficult to make holistic connections (as associated with agroecology for example, see Sevilla Guzmán and Woodgate, 1998). As a result it has been difficult for many actors to construct viable and integrated alternatives, or to harness the necessary spatial, natural, regional and knowledge-based resources necessary to progress *real* rural development options.

The broader field of rural development, as well as that of agro-food, has also become increasingly populated with project managers, consultants, exchange agents, etc., such that a profession has been established to which some are excluded. Moreover, current priorities of national governments concern the reconciling of the demands and risks of the 'careful consumer'. In the agro-food sector this is largely done by assembling a bureaucratic-hygienic apparatus – itself something of a new compromise between governments and capital – in order to stave off a further and potentially deeper consumer-led legitimization crisis in the old industrial system as a whole. In this context 'primary producers' – those nearest to the natural land-base – are continually disempowered. This has most recently been exposed in the UK with the government's responses to the 2001 foot and mouth outbreak, where regulatory controls on the movement and selling of livestock is hastening the demise of the smaller farms through the closure of livestock markets. Indeed the paradox of the story to eradicate BSE and other risks from the industrial food chain has been that the regulatory responses to it have further embedded industrial systems of supply, processing and retailing in the livestock and meat sectors.

There is a need, therefore, for rural social scientists to contest these regulatory modes and to apply other, for instance, agroecological and food ecological models to rural realities. This will require us to explore the contradictions and practices embedded in the different modes of environmental policy discourse, and for us to challenge the specificity of environmental expertise and professionalization. How can a more holistic food ecology be created? And, what novel forms of regulation would this require? Is the bureaucratic–hygienic mode sustainable over time and space? And what barriers does it place upon achieving real ecological modernization? For instance, while the current agro-environmental policy and rural development discourse continues apace in the European Commission, we see in Finland, the rapid structural concentration of farms occurring as a result of the CAP. The surface waves of ecological modernization discourses often seem to obscure the deeper countervailing currents of structural changes in the agro-food sector.

Conclusions: Looking Through the Environmental Maze

Past analyses in rural sociology, and to a large extent in environmental sociology more generally (see Redclift and Woodgate, 1998), have been built upon sophisticated and critical interpretations of the (agro-)industrial modernization project. In rural development terms, for example, this has focused upon challenging the prevailing economic notions of scale, critical mass, centralization, globalization and marginalization that this model has clearly engendered. Ecological modernization, in all of its shades, nuances and theoretical flaws, at least brings forth a new question. That is, how could/should the contested relationships between civil society, the state and the market be rearranged in ways which would usher in different types of autonomous development which would incorporate ecological worth?

A 'new age' of ecology, however, has begun in a slow, fledgling and uneven way, and it demands significant comparative analysis. It is argued here that it does, however, have some real intellectual purchase, and that part of this allows us to overcome some of the theoretical rigidities and obstacles of the past. Furthermore, part of its value is that it brings the need for an enhanced spatial sophistication and problematization back into a central arena in rural sociology. In addition, it opens the door to more theoretical pluralism, debate and progress, moving beyond binary social constructivist versus realist debates, structure and agency, and macro and micro concerns. Hence, the brief accounts of some key concerns are elaborated here as examples of how a stronger social-environmental and rural sociological enterprise might be forged. The concepts are by no means exclusively the preserve of either sub-discipline. However, they represent central critical connections or bridgeheads through which such disciplines and theories could be progressed.

An attempt has been made here then to set out some of the cardinal conceptual reference points and dialectics which are currently relevant for taking forward a more productive and creative engagement between ecological modernization theory and rural sociology. These are partly empirically grounded as well as theoretically constructed arguments and, as such, they deserve much more expansion, debate and consideration than is feasible in this short paper.

However, one of the fruitful opportunities such an exercise begins to present is the possibility of reassembling conceptual frameworks in ways which integrate nature and space within the broader political economy of local, national and international ruralities. As we see from the discussion above, many of the current environmental discourses and regulatory frameworks tend to fracture and fragment such integrative endeavours in such ways as to create false divisions of professional labour and interests between different communities of interest (including academics, policy officials, environmental NGOs, consultants and a whole range of 'project managers' who are now engaged in competitively progressing rural development initiatives). This makes integration in ecological policy development and implementation all that more difficult, and it leads to the driving out of a more radical consideration of alternatives (or 'deeper' form of ecological modernization) by the urgency of meeting bureaucratically applied performance measures and indicators. Hence, the more holistic and critical development of environmental and rural social science is now a central task in *creatively engaging with what might be, as well as what is*. For instance, to not only accept that ecological modernization is a highly contested and partial process, but to explore its further empirical and theoretical potentialities in creating the spaces for autonomous action, institutional reforms and development. The conceptual starting points outlined here are in this sense 'middle level' concepts which can start to address this task. We should remember that the agroindustrial modernization project has developed an elaborate and justificatory social science with which to legitimize and institutionalize itself; yet an equivalent rural social science for ecological modernization and rural development is still very much in its infancy, and liable to marginalization and dependency rather than autonomy and development.

Notes

1 The arguments developed here draw upon three research projects being conducted by the author and several colleagues (including Paul Milbourne, Jon Murdoch, Kevin Bishop). The first was entitled *Innovation and quality in the food chain: strengthening the regional dimension* funded by the Economic and Social Research Council. The second is entitled *The Socio-economic impact of rural development policies: realities and potentials* funded by the EU; and the third related to an ethnographic study, *Forestry, community and land in the South Wales Valleys* funded by the UK Forestry Commission. The early results emanating from these projects are containedin recent articles (see Murdoch et al, 2000; Bishop et al, 2001; Marsden et al, 2003).

2 The Forestry Commission is the main state-sponsored body for owning and managing forest lands in the UK.

3 Some recent and important evidence suggests that even those EU schemes which are associated with attempting to alleviate rural territorial disparities (such as Less Favoured Areas policies) are also tending to increase rather than decrease them. Shucksmith (2003) reported that richer and more prosperous regions tend to capture a higher proportion of such EU funds.

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List of Acronyms and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ACUNU	American Council for the United Nations University
AEA	Agroecosystems Analysis
AECI	Agency for International Cooperation
AKIS	agricultural knowledge and information system
BSPS	Beef Special Premium Scheme
CADA	Command Area Development Authority
CAP	Common Agricultural Policy
CDR	complex, diverse and risk prone
CIP	International Potato Centre (Peru)
CLCA	Claveria Land Care Association
CLOA	Certificate of Land Ownership Award
CSP	Conservation Security Program
CSWCRTI	Central Soil and Water Conservation Research and Training Institute
CTE	Contrat Territoriale d'Exploitation
DA	Department of Agriculture
DAR	Department of Agrarian Reform
DAS	days after sowing
DELTA	Beneficiary Assessment, Development Education Leadership Teams
DFID	Department for International Development
DLO	Dienst Landbouwkundig Onderzoek
DLV	Dienst Landbouwvoorlichting
DRP	Diagnóstico Rurale Participativo
DRSS	Department of Research and Specialist Services
EE	executive engineer
EQIP	Environmental Quality Incentives Program
ESAP	Economic Structural Adjustment Programme
EU	European Union
FAO	UN Food and Agriculture Organization
FEZ	Friese Ecologische Zuivelfabriek
FFS	farmer field schools
FSRU	Farming Systems Research Unit
GRAAP	Groupe de Recherche et d'Appui pour l'Auto-Promotion Paysanne

GST	General Systems Theory
HBP	Hasdeo Bango Project
HYV	high-yielding variety
I/O	input/output
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IER	Institut d'Economie Rurale
IIASA	International Institute for Applied Systems Analysis
IIED	International Institute for Environment and Development
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
LAWM	Latin American World Model
LFA	Less Favoured Area
LGU	local government units
LNV	Ministerie van Landbouw, Natuurbeheer en Visserij
MARP	Méthode Accélérée de Recherche Participative
MBRLC	Mindanao Baptist Rural Life Centre
MRB	Mahi Right Bank
MRP	Mahanadi River Project
NAIDP	Ned Agro-Industrial Development Project
NARS	national agricultural research system
NGO	non-governmental organization
NLCA	Ned Landcare Association
NSA	Nitrate Sensitive Area
NVS	natural vegetative strips
NVZ	Nitrate Vulnerable Zone
OFM	on-farm development
PALM	Participatory Analysis and Learning Methods
PAR	Participatory Action Research
PBR	People's Biodiversity Registers
PRA	Participatory Rural Appraisal
PRAP	Participatory Rural Appraisal and Planning
PRM	Participatory Research Methodology
PTD	Participatory Technology Development
PUA	Participatory Urban Appraisal
R&D	research and development
RA	Rapid Appraisal
RAAKS	Rapid Assessment of Agricultural Knowledge Systems
RAP	Rapid Assessment Procedures
RASE	Royal Agricultural Society of England
RAT	Rapid Assessment Techniques
RCA	Rapid Catchment Analysis
REA	Rapid Ethnographic Assessment

REFLECT	Regenerated Freiréan Literacy through Empowering Community Techniques
RFSA	Rapid Food Security Assessment
RMA	Rapid Multi-perspective Appraisal
ROA	Rapid Organizational Assessment
RRA	Rapid Rural Appraisal
SALT	Sloping Agricultural Land Technology
SAPS	Sheep Annual Premium Scheme
SAS	Statistical Analysis Systems
SCPS	Suckler Cow Premium Scheme
SDC	Swiss Agency for Development and Cooperation
SEARCA	Southeast Asian Regional Centre for Graduate Study and Research in Agriculture
SFI	Soil-Fertility Initiative
SRI	System of Rice Intensification
SPSS	Statistical Package for Social Sciences
SSM	Soft Systems Methodology
SWC	soil and water conservation
TOT	transfer of technology
USAID	United States Agency for International Development
VIPP	Visualization in Participatory Programmes
VROM	Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer
WAPCOS	Water and Power Consultancy Services
WKKF	W. K. Kellogg Foundation
WMSP	Water Management Synthesis Project
WQIP	Water Quality Incentive Program
WRI	World Resources Institute
WTC	Water Technology Centre
WTO	World Trade Organization

Editorial Introduction to Volume IV

Jules Pretty

Food Systems Overview: The Wider Policy Context

By the early 21st century, several things had become clear from evidence on the recent spread of agricultural sustainability in both industrialized and developing countries:

- Many technologies and social processes for local scale adoption of more sustainable agricultural systems were increasingly well-tested and established.
- The social and institutional conditions for spread were less well understood, but had been established in several contexts, leading to more rapid spread during the 1990s–early 2000s.
- The political conditions for the emergence of supportive policies were the least well established, with only a few examples of significant progress on reform.

Sustainable agriculture has been shown to be able to contribute to increased food production, as well as makes a positive impact on environmental goods and services. Clearly much can be done with existing resources, but a wider transition towards a more sustainable agriculture will not occur without more explicit external institutional and financial support. There are always transition costs in developing new or adapting old technologies, in learning to work together and in breaking free from existing patterns of thought and practice. It also costs time and money to rebuild depleted natural and social capital.

Most agricultural sustainability improvements in developing and industrialized countries occurring in the 1990s and early 2000s appear to have arisen despite existing national and institutional policies, rather than because of them. Although almost every country would now say it supports the idea of agricultural sustainability, the evidence points towards only patchy reforms. Only three countries have given explicit national support for sustainable agriculture: Cuba has a national policy for alternative agriculture; Switzerland has three tiers of support to encourage environmental services from agriculture and rural development; and Bhutan has a national environmental policy coordinated across all sectors. But even in these countries, there remains much to do.

Several countries have given sub-regional support to agricultural sustainability, such as the states of Santa Caterina, Paraná and Rio Grande do Sul in southern Brazil supporting zero-tillage, catchment management and rural agribusiness development, and some states in India supporting participatory watershed and irrigation management. A larger number of countries have reformed parts of agricultural policies, such as China's support for integrated ecological demonstration villages, Kenya's catchment approach to soil conservation, Indonesia's ban on pesticides and programme for farmer field schools, Bolivia's regional integration of agricultural and rural policies, Sweden's support for organic agriculture, Burkina Faso's land policy, and Sri Lanka and the Philippines' stipulation that water users' groups be formed to manage irrigation systems. In Europe and the US, a number of agri-environmental schemes have been implemented in the past decade, though their success has as yet only been patchy.

A good example of an integrated programme comes from China. In March 1994, the government published a White Paper to set out its plan for implementation of Agenda 21, and put forward ecological farming, known as *Shengtai Nongye* or agroecological engineering, as the approach to achieve sustainability in agriculture. Pilot projects have been established in 2000 townships and villages spread across 150 counties. Policy for these 'eco-counties' is organized through a cross-ministry partnership, which uses a variety of incentives to encourage adoption of diverse production systems to replace monocultures. These include subsidies and loans, technical assistance, tax exemptions and deductions, security of land tenure, marketing services and linkages to research organizations. These eco-counties contain some 12 million hectares of land, about half of which is cropland and, though only covering a relatively small part of China's total agricultural land, they illustrate what is possible when policy is appropriately coordinated.

What we do not yet know is whether progress towards more sustainable agricultural systems will result in enough food to meet the current food needs in developing countries, let alone the future needs after continued population growth and adoption of more urban and meat-rich diets. But what is occurring should be cause for cautious optimism, particularly as evidence indicates that productivity can grow over time if natural, social and human assets are accumulated. A more sustainable agriculture that improves the asset base can lead to rural livelihood improvements. People can be better off, have more food, be better organized, have access to external services and power structures, and have more choices in their lives.

But like all major changes, such transitions can also provoke secondary problems. For example, building a road near a forest can help farmers reach food markets, but also aid illegal timber extraction. Projects may be making considerable progress on reducing soil erosion and increasing water conservation through adoption of zero-tillage, but still continue to rely on applications of herbicides. If land has to be closed off to grazing for rehabilitation, then people with no other source of feed may have to sell their livestock; and if cropping intensity increases or new lands are taken into cultivation, then the burden of increased workloads may fall particularly on women. Also additional incomes arising from sales of produce may go directly to men in households, who are less likely than women to invest in children and the household as a whole. New winners and losers will emerge with the widespread adoption of sustainable agriculture. Producers of current agrochemical products are likely to suffer market losses from a more limited role for their products. The increase in assets that could come from sustainable agriculture may simply increase the incentives for more powerful interests to take over. Not all political interests will be content to see poor farmers and families organize into more powerful social networks and alliances.

Many countries also have national policies that promote export-led agricultural development. Access to international markets is clearly important for small farmers, and successful competition for market share can be a significant source of foreign exchange for poorer countries. However, this approach has some drawbacks:

- Poor countries are in competition with each other for market share, and so there is likely to be a downward pressure on prices, which reduces returns over time unless productivity continues to increase.
- Markets for agrifood products are fickle, and can be rapidly undermined by alternative products or threats (e.g. avian bird flu and the collapse of the Thai poultry sector).
- Distant markets are less sensitive to the potential negative externalities of agricultural production and are rarely pro-poor (with the exception of fair trade products).
- Smallholders have many difficulties in accessing international markets and market information.

More importantly, an export-led approach can seem to ignore the in-country opportunities for agricultural development focused on local and regional markets. Agricultural policies with both sustainability and poverty-reduction aims should adopt a multi-track approach that emphasizes: (1) small farmer development linked to local markets; (2) agribusiness development – both small businesses and export-led; (3) agro-processing and value-added activities – to ensure that returns are maximized in-country; (4) urban agriculture – as many urban people rely on small-scale urban food production that rarely appears in national statistics; and (5) livestock development – to meet local increases in demand for meat (predicted to increase as economies become richer).

A differentiated approach for agricultural policies will become increasingly necessary if agricultural systems themselves are to become more productive and sustainable whilst reducing negative impacts on the environment. This will require wider attention to exchange rate policies, trade reforms, domestic agricultural prices, input subsidies, labour market reforms, education and investment in schools, rural infrastructure, secure property rights to water and land, development of institutions for resource management, and substantial investments in agricultural research and extension. At the same time, the environmental costs of transporting food are increasing, and in some countries are greater than the costs arising from food production on farms, suggesting that sustainability priorities need to be set for whole food chains.

Part I: Ethics and Systems Thinking

Aldo Leopold was a conservation biologist made famous by both his writings in *A Sand County Almanac* and his transformation of a farm at Baraboo by the Wisconsin River. 'The Land Ethic' is a short essay from the late 1940s that sets out his views on human relations with the land – which he takes to include the community of soils, waters, plants and animals. In the face of damage to all of these caused by human action, he sets out the need for a mode of guidance. 'An ethic', he says, 'ecologically, is a limitation on freedom of action in the struggle for existence. An ethic, philosophically, is a differentiation of social from antisocial conduct.' This antisocial conduct partly derives from the narrow way we tend to view the land relation, namely a strictly economic one, 'entailing privileges but not obligations'. The language of the essay is at times stilted and dated, but the timing was impeccable. Ecological systems are so complex that their workings may never be fully comprehended. Yet we often act as if we know enough. Leopold further explores the dilemma of environmental education and the difficulty of changing mindsets. The problem with formal education, he says is that 'we have more education but less soil, fewer healthy woods and as many floods'. The Land Ethic was visionary and, with his other writings, Leopold was able to set out what needed to be done to change the way we all think and act.

One of the world's most notable and early thinkers on sustainability in agricultural systems was Masanobu Fukuoka, who wrote the concise and thoughtful *The One-Straw Revolution* in 1978. As a Japanese farmer himself, Fukuoka put into practice his own principles for natural farming. His concerns were this as he looked across to his neighbour's field: 'these rice fields, which have been found continuously for over 1500 years, have now been laid waste by the exploitative farming practices of a single generation'. This short chapter sets out Fukuoka's four principles of natural farming: no cultivation of the soil, no chemical fertilizer or prepared compost, no weeding by tillage or herbicides and no dependence on chemical intervention. The result is a permaculture of diverse crops, alongside dragonflies, moths, bees, spiders, frogs, lizards and many other small animals. This for him is the balanced rice field ecosystem.

Richard Bawden then develops the theme of knowing systems and the environment in the third article. Once again, the problem lies in how we have come to risk the world on the back of great recent achievements in economic and technological development. The chapter focuses on systems, both hard and soft, and on coming to know. Our quest, says Bawden, in seeking to come to terms with sustainability, must start with learning. What do we think we mean when we use terms like development and sustainability? We have made the world as it is, and so it is up to us collectively to make meaning through our learning. In a state of denial, about how bad circumstances are, we are going to need to devise different ways to think, interact and act very quickly. An important contrast centres on how we conceptualize systems ideas, and thus bring some cognitive coherence to bear on a complex world. Earlier pioneers of systems thinking focused on cybernetic regulative processes that maintained steady states, and many ideas about resilience and adaptation have since been developed. But strangely, systems ideas in the social sciences have seen declining support in recent decades. Another conceptualization, however, centres less on systems in the world, and more on systems of cognition, in which inquiry about the world is the soft system that can be both revealing and transformative. In this way, learning becomes less about the acquisition of knowledge, and more about the transformation of experience, whereby knowledge is fluid, being created, recreated and used by individuals as they seek to make sense of the world. The quest for sustainability focuses on new types of engagement between people with their different worldviews and paradigms, and the world about us.

In the fourth chapter, philosopher Paul Thompson explores the nature of agricultural sustainability. Philosophers spend a large part of their time scrutinizing words and concepts, attempting to get clear on what they mean, and on the implications of their meaning for human endeavours. Philosophy can help clarify hidden assumptions in alternative definitions and approaches to sustainability. Current usage reveals two main substantive approaches, resource sufficiency and functional integrity, as well as widespread non-substantive usage intended to promote social action. Although accounting-based resource sufficiency approaches have been the main focus in technical approaches, functional integrity approaches may be more transparent with respect to value judgements that inform the notion of sustainable systems. The 'paradox of sustainability' arises because substantive, research-based approaches to sustainability may be too complex to effectively motivate appropriate social responses. Nevertheless, debate over the meaning of sustainability can stimulate a fuller appreciation of the complex empirical processes and potentially contestable values that are implicated in any attempt to accomplish sustainability in agriculture.

Robert Chambers' *Managing Canal Irrigation* was published in the 1980s at a time when agricultural practices in many parts of the world were seeking to develop methods to offset the inherent personal and institutional biases that prevented clear understanding of conditions as poor people experienced them. Canal irrigation systems represent a particular type of system in which the poor and the tailenders are often forgotten. This chapter focuses on learning and mislearning, which at that point of time had not been the subject of much research. Yet it is how beliefs are formed and sustained that influences what professionals see. Irrigation systems in Gujarat and Madhya Pradesh are analysed, and these reveal the need for open learning systems. One problem is that trial areas receive special treatment at the beginning of projects, which are then assumed to represent the same conditions for all farmers. These special project areas are much visited and reported on, and again give the misleading impression that the same kinds of success are occurring everywhere. Privileged water, supplied at the cost of other parts of a system, is another special problem, appearing again to illustrate to unthinking professionals that their projects are successful.

Part II: Participatory Processes

In the first article, drawn from the seminal 1989 book *Farmer First*, Robert Chambers discusses the reversals necessary to put farmers' knowledge and capacities at the heart of agricultural transformations. For decades, agricultural research and extension institutions have used a transfer-of-technology mode of working, with farmers and their communities simply as recipients of technologies and practices developed on research stations. A farmer first approach requires professionals to adopt different attitudes and behaviour, becoming, for example, convenors, catalysts, advisers, travel agents and supporters of farmers' own analyses, choices and experiments. The complex, diverse and risk-prone environments of many developing country contexts are not well-suited to homogenous technologies, however effective they have been on research stations. They require that professionals reverse past practices, and encourage farmers to conduct their own analyses and experiments, thus adapting and fitting technologies to their own situations. Such reversals of 'normal practice' also require institutional change, with policies and institutions needing to facilitate such efforts. As Chambers said, the stakes are high, and a decade and a half after this chapter was written, they remain disturbingly high for millions of people and their environments.

There is a long history of participation in agricultural development; and a wide range of development agencies, both national and international, have attempted to involve people in some aspect of planning and implementation. Two overlapping schools of thought and practice have evolved. One views participation as a means to increase efficiency, the central notion being that if people are involved, then they are more likely to agree with and support the new development or service. The other sees participation as a fundamental right, in which the main aim is to initiate mobilization for collective action, empowerment and institution building. As a result, the terms 'people's participation' and 'popular participation' are now part of the normal language of many development agencies, including non-governmental organizations (NGOs), government departments and banks. It is such a fashion that almost everyone says that participation is part of their work. This has created many paradoxes. The term 'participation' has been used to justify the extension of control of the state as well as to build local capacity and self-reliance; it has been used to justify external decisions as well as to devolve power and decision making away from external agencies; it has been used for data collection as well as for interactive analysis. In this chapter by Jules Pretty, the many ways that development organizations interpret and use the term participation are resolved into a typology of seven clear uses. These range from manipulative and passive participation, where people are told what is to happen and act out predetermined roles, to self-mobilization, where people take initiatives largely independent of external institutions. This suggests that new systems of learning are needed, using participatory methods and criteria for establishing trustworthiness. These have profound implications for agricultural professionals, who must now actively create a whole new professionalism.

Jan Douwe van der Ploeg has contributed a great deal to our understanding of the motivations and actions of farmers and their 'farming styles'. In this first chapter from *The Virtual Farmer*, he explores and takes forward the idea of a storylines framework, which interweaves and interconnects in particular places. These storylines are important to van der Ploeg. The first concerns agriculture as a complex practice, as a carefully coordinated effort to mobile resources, to convert these resources into end products, and then the sale of these end products. The second storyline concerns the heterogeneity of farming as an expression of a 'dance through time'. The third storyline is a systematic critique of various forms of determinism – technological, economic and structural. This opening chapter addresses past, present and future, in which actors create projects, and collaborate or compete. Time is important, as desired future outcomes reach back to the present to affect actors in different ways.

Integrated Pest Management has been increasingly spread to farmers of a wide variety of agricultural systems. Perhaps the most successful advances have occurred in the rice-based systems of Asia. This article by Marc Barzman and Sylvie Desilles describes the experience of CARE-Bangladesh over an eight-year period, which has raised agricultural productivity by diversifying agroecosystems, reducing the costs of production, and creating new income sources for small farmers. Some 150,000 farmers have been involved in the programme, which has emphasized five technologies: (1) sustainable agricultural practices in rice; (2) vegetable production on rice field dykes; (3) fish production inside the rice field; (4) production of fish fingerlings; and (5) tree planting on rice field dykes. The main institutional mechanism to promote change is the farmer field school, in which farmers are trained over the course of a season in new approaches, and during which they come to appreciate the value of experimentation and sharing of results amongst one another. The article documents the economic benefits of the programme, as well as the non-economic ones, which include better nutrition, improved environments, and empowerment of farmers and their communities. There remain difficulties, though, particularly in ensuring participation of the very poorest families, and the reorganization of agricultural services and suppliers to the new agroecological systems that have emerged.

In the final article, Madhav Gagdil, colleagues and members of the People's Biodiversity Initiative show how folk knowledge and wisdom can be maintained. Gadgil indicates that such folk knowledge is transmitted and augmented almost entirely in the course of applying it in practice, but as it generally lacks a formal institutionalized process, it is vulnerable to changing relationships between people and their ecological resource base. In developing countries like India, people have access to newer resources, but are at the same time losing control over local resources, with the state and corporate taking over local interests. The programme of the People's Biodiversity Registers (PBRs) is an attempt to create a new institutional content for the continued use and development of indigenous knowledge.

The article summarizes the experience of organizing the preparation of 52 PBRs across the major ecosystems of India. The entire programme engaged 350 researchers and 200 assistants from village communities. The research found consistent increases in agricultural, wood, fish and shrimp production, but outside managed agroecosystems, there has been a widespread decline in both productivity and diversity of living resources. They document the breakdown of localized authority and rules for resource management, and even the case of a village in Rajasthan that used to be called the village of the medicine men, Vaidyonki Devli, but had now been renamed Devli because of the severe depletion of medicinal plant resources in the locality. They also recorded a decline in ecological knowledge amongst young people, though with some exceptions, such as where youth are still involved in fishing as a profession. In only two of the cases had there been spontaneous establishment of new regimes of regulated use that had led to resource recovery.

Part III: Governance and Education

Cees Leeuwis' 2004 book *Communication for Rural Innovation* contains a clear and insightful update of agricultural extension theory and practice, and this article, chapter 2 from the book, addresses the shift from extension to communication for innovation. The challenges for extension are changing rapidly, as recognition of different conditions and cultures grows. This chapter focuses first on an historical overview of how extension has been seen in the past – primarily implying that something is passed from someone or some institution who knows to someone else who does not know. It seeks to extend, and those who do not adopt the progressive message or technology are commonly seen as laggards or backward. It is their fault that they have not changed their practices (even if they themselves have very good reason for rejection). Leeuwis proposes a novel definition for extension here, even though some writers have suggested the abandonment of the term altogether because of its unidirectional connotations. In practice, communication for innovation can take many forms, and these are discussed in detail, together with concepts of knowledge systems, extension education, extension research and extension science. A new definition for extension emerges from these debates.

The second paper by K. L. Heong and colleagues describes a rare discovery – a simple technology, in this case a practice, that can be spread widely amongst farmers that brings both economic and environmental benefits. The problem is that many rice farmers spray insecticides based on their perceptions of potential damage and losses caused by pests. Farmers generally overestimate the seriousness of leaf damage caused by a variety of leaf-feeding insects, and so start applying insecticides. Yet damage to the rice crop during the vegetative stage rarely affects yields, even if as much as 40 per cent of a leaf is consumed. Early applications of insecticide are therefore unnecessary. This paper describes the testing and spreading of a simple heuristic or rule of thumb to Vietnamese farmers in the Mekong Delta: 'Spraying insecticides for leaf folder control in the first 40 days after sowing is not needed.' A wide range of communication media were used to spread this simple message. Two and half years after the media introduction, insecticide sprays had fallen from 3.4 to 1.6 per season, saving farmers both insecticide and labour costs. The practice was then spread to 200,000 farmers in Long An, and then to the whole Mekong Delta of 2 million farmers.

The slow adoption of conservation farming systems in the uplands of the Philippines is the focus of the third paper by Rob Cramb and Z. Culasero. Agricultural degradation in the densely populated, steeply sloping regions has long been recognized as a major environmental problem, with significant on- and off-site impacts. A variety of effective conservation farming methods based on contour hedgerows of shrub legumes had been developed, yet sustained uptake by farmers was limited. This paper focuses on the potential of the landcare approach to develop new forms of collective action at the local levels. Landcare centres on the formation of community groups, supported by varying degrees through partnerships with government and non-government agencies. The paper specifically reports on the impacts of such an institution-building approach in southern Mindanao. The main effect of the programme was to enhance human capital through practical, farmer-led training and extension, enabling farmers to incorporate soil conservation and agroforestry technologies into their farming systems. The social capital formed, especially through the landcare associations, was critical to these outcomes. Strong partnerships will be required in future if such progress is to be sustained, and then spread to other communities.

Wendell Berry is one of the best known writers on agrarian pasts and presents in North America. He is a practising farmer, poet and author of many books. In this excerpt from his 1976 book, *The Unsettling of America*, he tells the story of the change in culture and agriculture in a few short generations of frontier invasion, spread and modernization. America was not settled, but unsettled, and it resulted in the exploitation of the land and its people. It ultimately, too, undermined the environmental security and health of the settlers. The production treadmill based on competition and degradation resulted in the loss of family farmers from the land – a process that has continued at a faster pace since the writing of this chapter in the 1970s. As he says, 'the care of the earth is our most ancient and most worthy and, after all, our most pleasing responsibility'. To cherish what remains of it, and to foster renewal, is our only legitimate hope.

Education in agroecology, agricultural systems and sustainable agriculture can provide students with a broad curriculum that deals with the interaction among production, economic, environmental and social dimensions of farming and food systems. Courses in agroecology and organic farming are now becoming more prevalent on university campuses in the Nordic region, Europe, US and elsewhere. Geir Lieblin and colleagues observe that in most programmes and courses the teaching methods have departed little from a strong emphasis on transmitting information through lectures, some discussion and library readings, and periodic trips to farms that often turn into lectures in the field. Adult education provides an appropriate set of methods for learning about the complexities of farming systems. Agroecology provides a new framework to organize learning opportunities for students interested in solving challenges in today's world. The authors' programmes in agroecology concentrate on discovery and learning. Rather than agroecological theory having primary value, they immerse students in practical phenomena at the farming and food system level, and let these phenomena determine what theory is necessary and relevant. Teachers are converted from lecturers to leaders and catalysts in the learning process.

Part IV: Enabling Policies and Institutions

The first chapter in Niels Roling and Annemarie Wagemakers' 1998 book *Facilitating Sustainable Agriculture* sets out a series of significant challenges for actors and institutions engaged with agricultural development and the sustainability project. Five interlocking dimensions are identified, including agricultural practices, learning these practices, facilitating that learning, institutional frameworks that support such facilitation, and conducive policy frameworks. Sustainability is seen as an emergent property of systems – the outcome of the collective decision making that arises from interaction among stakeholders. The formulation of sustainability in this manner implies that the definition is part of the problem that stakeholders have to resolve. This chapter describes the social energy required to make the flip, and explores the prevalent paradigm for thinking about innovation (which gets in the way of progress towards sustainability). Constructionism is the term given to the epistemology which supports learning processes described in this book. If everyone agrees about the goals, we can afford to worry about the best technological means of securing those goals. If everyone agrees about the facts, we can speak of objective truth. But these conditions rarely hold, and as reality is no longer a given, then it becomes something that has to be constructed by people.

John Kerr and colleagues address a pervasive problem in agricultural development. If farmers are paid to do something, such as adopt a new crop or build a terrace, then they are not likely to question the choice of technology, nor to adapt it to their own conditions. At the same time, external professionals are not challenged to ensure that technologies do indeed fit local conditions and needs. In this paper, the use of subsidies in watershed development in India is analysed. The authors do not argue that government support for agriculture and poverty alleviation should not be given. Rather, they show that some unintended negative consequences of heavy subsidies actually undermine watershed development objectives. The problem is that subsidies are used to achieve both watershed development and employment generation, a lot to ask of any policy intervention. The consequences on the ground can be severe – villagers may praise contour bunds for water conservation when in the presence of government officials, yet destroy them when they leave. Villagers also agree that they would happily engage in inappropriate soil and water conservation activities if these were a way to obtain additional employment. Kerr and colleagues suggest alternative ways to manage subsidies for watershed development.

The third paper by Thomas Dobbs and Jules Pretty is an analysis of the effectiveness of agrienvironmental schemes in the UK. Agriculture is now being seen more as a multifunctional activity – it does more than just produce food. The side effects, both positive and negative, have important implications on local and national ecological and social systems. This idea of multifunctionality is now being internalized into policies so that financial support can be used to encourage the flow of environmental goods and services from specific landscapes. The UK introduced the first agrienvironmental scheme in the European Union (EU) in 1986, and since then it has developed and implemented several other schemes that also feature stewardship payments to improve agriculture's environmental performance. In this article, lessons learned from the UK's various agrienvironmental programmes are identified. The paper examines three key sets of issues associated with possible major expansions of *stewardship payment* programmes. These issues concern: (1) the compatibility of production support and stewardship support; (2) balancing stewardship payments and environmental compliance; and (3) the compatibility of World Trade Organization rules with stewardship schemes. Using the concept of 'multifunctionality', which increasingly is influencing agricultural policy in Europe, the authors examine key issues associated with potential major expansions of stewardship payment schemes on both sides of the Atlantic.

Ian Scoones' 2001 book *Dynamics and Diversity* emphasizes throughout the importance of taking local context seriously. Some of the key findings include understanding how farmers classify their own soils, and also seek to improve them over time. Africa's farming systems are highly diverse, and this diversity is a key feature at all scales. It is important for farmers as it reduces the risk of crop failure. Farming systems are dynamic, and there is no single pathway being followed by farmers at one site. Farmers' management of soil nutrients depends on a range of socioeconomic factors, and data on nutrient balances shows how there is a mixed pattern of accumulation and depletion, depending on plots, farmers and locations. Finally, farmers have all been affected by recent policy changes. This is the specific context for this chapter by Ian Scoones and Camilla Toulmin. This diversity of agroecological settings demands a differentiated approach for intervention strategies and policy options. The technological choices are important, as they are highly contested in many circles. With respect to Ethiopia, Mali and Zimbabwe, a range of policies are discussed, including devolution and structural adjustment, credit, rural infrastructure, research and extension services, and land and tenure reform. The problem, though, is though a range of policies affect farm management of soil fertility, rarely has soil-fertility management been the main target of policies. A sustainable livelihoods approach to policy design is suggested as a way forward.

The final article in this volume is by Patricia Benjamin and colleagues and addresses social visions of future sustainable societies. The new globalized society is currently undergoing rapid political, economic and cultural change, and we are going to need clear social visions, or stories, to determine possible (and hopefully attainable) outcomes. Social sustainability, note the authors, does not mean the continuation of existing social structures, but rather the creation and maintenance of the conditions for creativity, empowerment, self-determination and self-actualization. The article reviews past efforts to understand visions for the future – a history of the future. Visions are stories of possible alternative futures, and the process of forming them may be viewed as a purposeful strategic choice. But discourses will need to be broad if visions are not to converge to a single model that could result in severe environmental destruction. Stories for divergence are required, and sustainable agricultural systems have a role to play in developing and maintaining such alternatives.

Part I

Ethics and Systems Thinking

1

The Land Ethic

A. Leopold

When god-like Odysseus returned from the wars in Troy, he hanged all on one rope a dozen slave-girls of his household whom he suspected of misbehaviour during his absence.

This hanging involved no question of propriety. The girls were property. The disposal of property was then, as now, a matter of expediency, not of right and wrong.

Concepts of right and wrong were not lacking from Odysseus' Greece: witness the fidelity of his wife through the long years before at last his black-prowed galleys clove the wine-dark seas for home. The ethical structure of that day covered wives, but had not yet been extended to human chattels. During the 3000 years which have since elapsed, ethical criteria have been extended to many fields of conduct, with corresponding shrinkages in those judged by expediency only.

This extension of ethics, so far studied only by philosophers, is actually a process in ecological evolution. Its sequences may be described in ecological as well as in philosophical terms. An ethic, ecologically, is a limitation on freedom of action in the struggle for existence. An ethic, philosophically, is a differentiation of social from antisocial conduct. These are two definitions of one thing. The thing has its origin in the tendency of interdependent individuals or groups to evolve modes of cooperation. The ecologist calls these symbioses. Politics and economics are advanced symbioses in which the original free-for-all competition has been replaced, in part, by cooperative mechanisms with an ethical content.

The complexity of cooperative mechanisms has increased with population density, and with the efficiency of tools. It was simpler, for example, to define the antisocial uses of sticks and stones in the days of the mastodons than of bullets and billboards in the age of motors.

The first ethics dealt with the relation between individuals; the Mosaic Decalogue is an example. Later accretions dealt with the relation between the individual and society. The Golden Rule tries to integrate the individual to society; democracy to integrate social organization to the individual.

Reprinted from Leopold A. 1949. The land ethic. In *A Sand Country Almanac and Sketches Here and There.* Oxford University Press, London. By permission of Oxford University Press, Inc.

There is as yet no ethic dealing with man's relation to land and to the animals and plants which grow upon it. Land, like Odysseus' slave-girls, is still property. The land-relation is still strictly economic, entailing privileges but not obligations.

The extension of ethics to this third element in human environment is, if I read the evidence correctly, an evolutionary possibility and an ecological necessity. It is the third step in a sequence. The first two have already been taken. Individual thinkers since the days of Ezekiel and Isaiah have asserted that the despoliation of land is not only inexpedient but wrong. Society, however, has not yet affirmed their belief. I regard the present conservation movement as the embryo of such an affirmation.

An ethic may be regarded as a mode of guidance for meeting ecological situations so new or intricate, or involving such deferred reactions, that the path of social expediency is not discernible to the average individual. Animal instincts are modes of guidance for the individual in meeting such situations. Ethics are possibly a kind of community instinct in-the-making.

The Community Concept

All ethics so far evolved rest upon a single premise: that the individual is a member of a community of interdependent parts. His instincts prompt him to compete for his place in the community, but his ethics prompt him also to cooperate (perhaps in order that there may be a place to compete for).

The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land.

This sounds simple: do we not already sing our love for and obligation to the land of the free and the home of the brave? Yes, but just what and whom do we love? Certainly not the soil, which we are sending helter-skelter downriver. Certainly not the waters, which we assume have no function except to turn turbines, float barges and carry off sewage. Certainly not the plants, of which we exterminate whole communities without batting an eye. Certainly not the animals, of which we have already extirpated many of the largest and most beautiful species. A land ethic of course cannot prevent the alteration, management and use of these 'resources,' but it does affirm their right to continued existence, and, at least in spots, their continued existence in a natural state.

In short, a land ethic changes the role of *Homo sapiens* from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow-members, and also respect for the community as such.

In human history, we have learned (I hope) that the conqueror role is eventually self-defeating. Why? Because it is implicit in such a role that the conqueror knows, *ex cathedra*, just what makes the community clock tick, and just what and who is valuable, and what and who is worthless, in community life. It always turns out that he knows neither, and this is why his conquests eventually defeat themselves.

In the biotic community, a parallel situation exists. Abraham knew exactly what the land was for: it was to drip milk and honey into Abraham's mouth. At the present moment, the assurance with which we regard this assumption is inverse to the degree of our education.

The ordinary citizen today assumes that science knows what makes the community clock tick; the scientist is equally sure that he does not. He knows that the biotic mechanism is so complex that its workings may never be fully understood.

That man is, in fact, only a member of a biotic team is shown by an ecological interpretation of history. Many historical events, hitherto explained solely in terms of human enterprise, were actually biotic interactions between people and land. The characteristics of the land determined the facts quite as potently as the characteristics of the men who lived on it.

Consider, for example, the settlement of the Mississippi valley. In the years following the Revolution, three groups were contending for its control: the native Indian, the French and English traders, and the American settlers. Historians wonder what would have happened if the English at Detroit had thrown a little more weight into the Indian side of those tipsy scales which decided the outcome of the colonial migration into the cane-lands of Kentucky. It is time now to ponder the fact that the cane-lands, when subjected to the particular mixture of forces represented by the cow, plough, fire and axe of the pioneer, became bluegrass. What if the plant succession inherent in this dark and bloody ground had, under the impact of these forces, given us some worthless sedge, shrub, or weed? Would Boone and Kenton have held out? Would there have been any overflow into Ohio, Indiana, Illinois and Missouri? Any Louisiana Purchase? Any transcontinental union of new states? Any Civil War?

Kentucky was one sentence in the drama of history. We are commonly told what the human actors in this drama tried to do, but we are seldom told that their success, or the lack of it, hung in large degree on the reaction of particular soils to the impact of the particular forces exerted by their occupancy. In the case of Kentucky, we do not even know where the bluegrass came from – whether it is a native species, or a stowaway from Europe.

Contrast the cane-lands with what hindsight tells us about the Southwest, where the pioneers were equally brave, resourceful and persevering. The impact of occupancy here brought no bluegrass, or other plant fitted to withstand the bumps and buffetings of hard use. This region, when grazed by livestock, reverted through a series of more and more worthless grasses, shrubs and weeds to a condition of unstable equilibrium. Each recession of plant types bred erosion; each increment to erosion bred a further recession of plants. The result today is a progressive and mutual deterioration, not only of plants and soils, but of the animal community subsisting thereon. The early settlers did not expect this: on the *ciénegas* of New Mexico some even cut ditches to hasten it. So subtle has been its progress that few residents of the region are aware of it. It is quite invisible to the tourist who finds this wrecked landscape colourful and charming (as indeed it is, but it bears scant resemblance to what it was in 1848).

This same landscape was 'developed' once before, but with quite different results. The Pueblo Indians settled the Southwest in pre-Columbian times, but they happened *not* to be equipped with range livestock. Their civilization expired, but not because their land expired.

In India, regions devoid of any sod-forming grass have been settled, apparently without wrecking the land, by the simple expedient of carrying the grass to the cow, rather than vice versa. (Was this the result of some deep wisdom, or was it just good luck? I do not know.)

In short, the plant succession steered the course of history; the pioneer simply demonstrated, for good or ill, what successions inhered in the land. Is history taught in this spirit? It will be, once the concept of land as a community really penetrates our intellectual life.

The Ecological Conscience

Conservation is a state of harmony between men and land. Despite nearly a century of propaganda, conservation still proceeds at a snail's pace; progress still consists largely of letterhead pieties and convention oratory. On the back forty we still slip two steps backward for each forward stride.

The usual answer to this dilemma is 'more conservation education'. No one will debate this, but is it certain that only the *volume* of education needs stepping up? Is something lacking in the *content* as well?

It is difficult to give a fair summary of its content in brief form, but, as I understand it, the content is substantially this: obey the law, vote right, join some organizations and practice what conservation is profitable on your own land; the government will do the rest.

Is not this formula too easy to accomplish anything worthwhile? It defines no right or wrong, assigns no obligation, calls for no sacrifice, implies no change in the current philosophy of values. In respect of land use, it urges only enlightened self-interest. Just how far will such education take us? An example will perhaps yield a partial answer.

By 1930 it had become clear to all except the ecologically blind that southwestern Wisconsin's topsoil was slipping seaward. In 1933 the farmers were told that if they would adopt certain remedial practices for five years, the public would donate Civilian Conservation Corps labour to install them, plus the necessary machinery and materials. The offer was widely accepted, but the practices were widely forgotten when the five-year contract period was up. The farmers continued only those practices that yielded an immediate and visible economic gain for themselves.

This led to the idea that maybe farmers would learn more quickly if they themselves wrote the rules. Accordingly the Wisconsin Legislature in 1937 passed the Soil Conservation District Law. This said to farmers, in effect: *We, the public, will furnish you free technical service and loan you specialized machinery, if you will* *write your own rules for land use. Each county may write its own rules, and these will have the force of law*. Nearly all the counties promptly organized to accept the proffered help, but after a decade of operation, *no county has yet written a single rule*. There has been visible progress in such practices as strip-cropping, pasture renovation and soil liming, but none in fencing woodlots against grazing, and none in excluding plough and cow from steep slopes. The farmers, in short, have selected those remedial practices which were profitable anyhow, and ignored those which were profitable to the community, but not clearly profitable to themselves.

When one asks why no rules have been written, one is told that the community is not yet ready to support them; education must precede rules. But the education actually in progress makes no mention of obligations to land over and above those dictated by self-interest. The net result is that we have more education but less soil, fewer healthy woods and as many floods as in 1937.

The puzzling aspect of such situations is that the existence of obligations over and above self-interest is taken for granted in such rural community enterprises as the betterment of roads, schools, churches and baseball teams. Their existence is not taken for granted, nor as yet seriously discussed, in bettering the behaviour of the water that falls on the land, or in the preserving of the beauty or diversity of the farm landscape. Land use ethics are still governed wholly by economic self-interest, just as social ethics were a century ago.

To sum up: we asked the farmer to do what he conveniently could to save his soil, and he has done just that, and only that. The farmer who clears the woods off a 75 per cent slope, turns his cows into the clearing and dumps its rainfall, rocks, and soil into the community creek, is still (if otherwise decent) a respected member of society. If he puts lime on his fields and plants his crops on contour, he is still entitled to all the privileges and emoluments of his Soil Conservation District. The District is a beautiful piece of social machinery, but it is coughing along on two cylinders because we have been too timid, and too anxious for quick success, to tell the farmer the true magnitude of his obligations. Obligations have no meaning without conscience, and the problem we face is the extension of the social conscience from people to land.

No important change in ethics was ever accomplished without an internal change in our intellectual emphasis, loyalties, affections and convictions. The proof that conservation has not yet touched these foundations of conduct lies in the fact that philosophy and religion have not yet heard of it. In our attempt to make conservation easy, we have made it trivial.

Substitutes for a Land Ethic

When the logic of history hungers for bread and we hand out a stone, we are at pains to explain how much the stone resembles bread. I now describe some of the stones which serve in lieu of a land ethic.

One basic weakness in a conservation system based wholly on economic motives is that most members of the land community have no economic value. Wildflowers and songbirds are examples. Of the 22,000 higher plants and animals native to Wisconsin, it is doubtful whether more than 5 per cent can be sold, fed, eaten or otherwise put to economic use. Yet these creatures are members of the biotic community, and if (as I believe) its stability depends on its integrity, they are entitled to continuance.

When one of these non-economic categories is threatened, and if we happen to love it, we invent subterfuges to give it economic importance. At the beginning of the century songbirds were supposed to be disappearing. Ornithologists jumped to the rescue with some distinctly shaky evidence to the effect that insects would eat us up if birds failed to control them. The evidence had to be economic in order to be valid.

It is painful to read these circumlocutions today. We have no land ethic yet, but we have at least drawn nearer the point of admitting that birds should continue as a matter of biotic right, regardless of the presence or absence of economic advantage to us.

A parallel situation exists in respect of predatory mammals, raptorial birds and fish-eating birds. Time was when biologists somewhat overworked the evidence that these creatures preserve the health of game by killing weaklings, or that they control rodents for the farmer, or that they prey only on 'worthless' species. Here again, the evidence had to be economic in order to be valid. It is only in recent years that we hear the more honest argument that predators are members of the community, and that no special interest has the right to exterminate them for the sake of a benefit, real or fancied, to itself. Unfortunately this enlightened view is still in the talk stage. In the field the extermination of predators goes merrily on: witness the impending erasure of the timber wolf by fiat of Congress, the Conservation Bureaus and many state legislatures.

Some species of trees have been 'read out of the party' by economics-minded foresters because they grow too slowly, or have too low a sale value to pay as timber crops: white cedar, tamarack, cypress, beech and hemlock are examples. In Europe, where forestry is ecologically more advanced, the non-commercial tree species are recognized as members of the native forest community, to be preserved as such, within reason. Moreover some (like beech) have been found to have a valuable function in building up soil fertility. The interdependence of the forest and its constituent tree species, ground flora and fauna is taken for granted.

Lack of economic value is sometimes a character not only of species or groups, but of entire biotic communities: marshes, bogs, dunes and 'deserts' are examples. Our formula in such cases is to relegate their conservation to government as refuges, monuments or parks. The difficulty is that these communities are usually interspersed with more valuable private lands; the government cannot possibly own or control such scattered parcels. The net effect is that we have relegated some of them to ultimate extinction over large areas. If the private owner were ecologically minded, he would be proud to be the custodian of a reasonable proportion of such areas, which add diversity and beauty to his farm and to his community.

In some instances, the assumed lack of profit in these 'waste' areas has proved to be wrong, but only after most of them had been done away with. The present scramble to reflood muskrat marshes is a case in point.

There is a clear tendency in American conservation to relegate to government all necessary jobs that private landowners fail to perform. Government ownership, operation, subsidy or regulation is now widely prevalent in forestry, range management, soil and watershed management, park and wilderness conservation, fisheries management and migratory bird management, with more to come. Most of this growth in governmental conservation is proper and logical, some of it is inevitable. That I imply no disapproval of it is implicit in the fact that I have spent most of my life working for it. Nevertheless the question arises: What is the ultimate magnitude of the enterprise? Will the tax base carry its eventual ramifications? At what point will governmental conservation, like the mastodon, become handicapped by its own dimensions? The answer, if there is any, seems to be in a land ethic, or some other force which assigns more obligation to the private landowner.

Industrial landowners and users, especially lumbermen and stockmen, are inclined to wail long and loudly about the extension of government ownership and regulation to land, but (with notable exceptions) they show little disposition to develop the only visible alternative: the voluntary practice of conservation on their own lands.

When the private landowner is asked to perform some unprofitable act for the good of the community, he today assents only with outstretched palm. If the act costs him cash this is fair and proper, but when it costs only forethought, open-mindedness or time, the issue is at least debatable. The overwhelming growth of land use subsidies in recent years must be ascribed, in large part, to the government's own agencies for conservation education: the land bureaus, the agricultural colleges and the extension services. As far as I can detect, no ethical obligation toward land is taught in these institutions.

To sum up: a system of conservation based solely on economic self-interest is hopelessly lopsided. It tends to ignore, and thus eventually to eliminate, many elements in the land community that lack commercial value, but that are (as far as we know) essential to its healthy functioning. It assumes, falsely, I think, that the economic parts of the biotic clock will function without the uneconomic parts. It tends to relegate to government many functions eventually too large, too complex, or too widely dispersed to be performed by government.

An ethical obligation on the part of the private owner is the only visible remedy for these situations.

The Land Pyramid

An ethic to supplement and guide the economic relation to land presupposes the existence of some mental image of land as a biotic mechanism. We can be ethical only in relation to something we can see, feel, understand, love, or otherwise have faith in.

The image commonly employed in conservation education is 'the balance of nature'. For reasons too lengthy to detail here, this figure of speech fails to describe accurately what little we know about the land mechanism. A much truer image is the one employed in ecology: the biotic pyramid. I shall first sketch the pyramid as a symbol of land and later develop some of its implications in terms of land-use.

Plants absorb energy from the sun. This energy flows through a circuit called the biota, which may be represented by a pyramid consisting of layers. The bottom layer is the soil. A plant layer rests on the soil, an insect layer on the plants, a bird and rodent layer on the insects and so on up through various animal groups to the apex layer, which consists of the larger carnivores.

The species of a layer are alike not in where they came from, or in what they look like, but rather in what they eat. Each successive layer depends on those below it for food and often for other services, and each in turn furnishes food and services to those above. Proceeding upward, each successive layer decreases in numerical abundance. Thus, for every carnivore there are hundreds of his prey, thousands of their prey, millions of insects, uncountable plants. The pyramidal form of the system reflects this numerical progression from apex to base. Man shares an intermediate layer with the bears, raccoons and squirrels which eat both meat and vegetables.

The lines of dependency for food and other services are called food chains. Thus soil-oak-deer-Indian is a chain that has now been largely converted to soil-corn-cow-farmer. Each species, including ourselves, is a link in many chains. The deer eats a hundred plants other than oak, and the cow a hundred plants other than corn. Both, then, are links in a hundred chains. The pyramid is a tangle of chains so complex as to seem disorderly, yet the stability of the system proves it to be a highly organized structure. Its functioning depends on the cooperation and competition of its diverse parts.

In the beginning, the pyramid of life was low and squat; the food chains short and simple. Evolution has added layer after layer, link after link. Man is one of thousands of accretions to the height and complexity of the pyramid. Science has given us many doubts, but it has given us at least one certainty: the trend of evolution is to elaborate and diversify the biota.

Land, then, is not merely soil; it is a fountain of energy flowing through a circuit of soils, plants and animals. Food chains are the living channels which conduct energy upward; death and decay return it to the soil. The circuit is not closed; some energy is dissipated in decay, some is added by absorption from the air, some is stored in soils, peats and long-lived forests; but it is a sustained circuit, like a slowly augmented revolving fund of life. There is always a net loss by downhill wash, but this is normally small and offset by the decay of rocks. It is deposited in the ocean and, in the course of geological time, raised to form new lands and new pyramids.

The velocity and character of the upward flow of energy depend on the complex structure of the plant and animal community, much as the upward flow of sap in a tree depends on its complex cellular organization. Without this complexity, normal circulation would presumably not occur. Structure means the characteristic numbers, as well as the characteristic kinds and functions, of the component species. This interdependence between the complex structure of the land and its smooth functioning as an energy unit is one of its basic attributes.

When a change occurs in one part of the circuit, many other parts must adjust themselves to it. Change does not necessarily obstruct or divert the flow of energy; evolution is a long series of self-induced changes, the net result of which has been to elaborate the flow mechanism and to lengthen the circuit. Evolutionary changes, however, are usually slow and local. Man's invention of tools has enabled him to make changes of unprecedented violence, rapidity and scope.

One change is in the composition of floras and faunas. The larger predators are lopped off the apex of the pyramid; food chains, for the first time in history, become shorter rather than longer. Domesticated species from other lands are substituted for wild ones, and wild ones are moved to new habitats. In this worldwide pooling of faunas and floras, some species get out of bounds as pests and diseases, others are extinguished. Such effects are seldom intended or foreseen; they represent unpredicted and often untraceable readjustments in the structure. Agricultural science is largely a race between the emergence of new pests and the emergence of new techniques for their control.

Another change touches the flow of energy through plants and animals and its return to the soil. Fertility is the ability of soil to receive, store and release energy. Agriculture, by overdrafts on the soil, or by too radical a substitution of domestic for native species in the superstructure, may derange the channels of flow or deplete storage. Soils depleted of their storage, or of the organic matter which anchors it, wash away faster than they form. This is erosion.

Waters, like soil, are part of the energy circuit. Industry, by polluting waters or obstructing them with dams, may exclude the plants and animals necessary to keep energy in circulation.

Transportation brings about another basic change: the plants or animals grown in one region are now consumed and returned to the soil in another. Transportation taps the energy stored in rocks and in the air, and uses it elsewhere; thus we fertilize the garden with nitrogen gleaned by the guano birds from the fishes of seas on the other side of the Equator. Thus the formerly localized and self-contained circuits are pooled on a worldwide scale.

The process of altering the pyramid for human occupation releases stored energy, and this often gives rise, during the pioneering period, to a deceptive exuberance of plant and animal life, both wild and tame. These releases of biotic capital tend to becloud or postpone the penalties of violence.

* * *

This thumbnail sketch of land as an energy circuit conveys three basic ideas:

1 That land is not merely soil.
2 That the native plants and animals kept the energy circuit open; others may or may not.
3 That man-made changes are of a different order than evolutionary changes, and have effects more comprehensive than is intended or foreseen.

These ideas, collectively, raise two basic issues: Can the land adjust itself to the new order? Can the desired alterations be accomplished with less violence?

Biotas seem to differ in their capacity to sustain violent conversion. Western Europe, for example, carries a far different pyramid than Caesar found there. Some large animals are lost; swampy forests have become meadows or ploughland; many new plants and animals are introduced, some of which escape as pests; the remaining natives are greatly changed in distribution and abundance. Yet the soil is still there and, with the help of imported nutrients, still fertile; the waters flow normally; the new structure seems to function and to persist. There is no visible stoppage or derangement of the circuit.

Western Europe, then, has a resistant biota. Its inner processes are tough, elastic, resistant to strain. No matter how violent the alterations, the pyramid, so far, has developed some new modus vivendi which preserves its habitability for man, and for most of the other natives.

Japan seems to present another instance of radical conversion without disorganization.

Most other civilized regions, and some as yet barely touched by civilization, display various stages of disorganization, varying from initial symptoms to advanced wastage. In Asia Minor and North Africa diagnosis is confused by climatic changes, which may have been either the cause or the effect of advanced wastage. In the United States the degree of disorganization varies locally; it is worst in the Southwest, the Ozarks and parts of the South, and least in New England and the Northwest. Better land uses may still arrest it in the less advanced regions. In parts of Mexico, South America, South Africa and Australia a violent and accelerating wastage is in progress, but I cannot assess the prospects.

This almost worldwide display of disorganization in the land seems to be similar to disease in an animal, except that it never culminates in complete disorganization or death. The land recovers, but at some reduced level of complexity, and with a reduced carrying capacity for people, plants and animals. Many biotas currently regarded as 'lands of opportunity' are in fact already subsisting on exploitative agriculture, i.e. they have already exceeded their sustained carrying capacity. Most of South America is overpopulated in this sense.

In arid regions we attempt to offset the process of wastage by reclamation, but it is only too evident that the prospective longevity of reclamation projects is often short. In our own West, the best of them may not last a century.

The combined evidence of history and ecology seems to support one general deduction: the less violent the man-made changes, the greater the probability of successful readjustment in the pyramid. Violence, in turn, varies with human population density; a dense population requires a more violent conversion. In this respect, North America has a better chance for permanence than Europe, if she can contrive to limit her density.

This deduction runs counter to our current philosophy, which assumes that because a small increase in density enriched human life, that an indefinite increase will enrich it indefinitely. Ecology knows of no density relationship that holds for indefinitely wide limits. All gains from density are subject to a law of diminishing returns.

Whatever may be the equation for men and land, it is improbable that we as yet know all its terms. Recent discoveries in mineral and vitamin nutrition reveal unsuspected dependencies in the up-circuit: incredibly minute quantities of certain substances determine the value of soils to plants, of plants to animals. What of the down-circuit? What of the vanishing species, the preservation of which we now regard as an aesthetic luxury? They helped build the soil; in what unsuspected ways may they be essential to its maintenance? Professor Weaver proposes that we use prairie flowers to reflocculate the wasting soils of the dust bowl; who knows for what purpose cranes and condors, otters and grizzlies may some day be used?

Land Health and the A-B Cleavage

A land ethic, then, reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land. Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity.

Conservationists are notorious for their dissensions. Superficially these seem to add up to mere confusion, but a more careful scrutiny reveals a single plane of cleavage common to many specialized fields. In each field one group (A) regards the land as soil, and its function as commodity-production; another group (B) regards the land as a biota, and its function as something broader. How much broader is admittedly in a state of doubt and confusion.

In my own field, forestry, Group A is quite content to grow trees like cabbages, with cellulose as the basic forest commodity. It feels no inhibition against violence; its ideology is agronomic. Group B, on the other hand, sees forestry as fundamentally different from agronomy because it employs natural species, and manages a natural environment rather than creating an artificial one. Group B prefers natural reproduction on principle. It worries on biotic as well as economic grounds about the loss of species like chestnut and the threatened loss of the white pines. It worries about a whole series of secondary forest functions: wildlife, recreation, watersheds, wilderness areas. To my mind, Group B feels the stirrings of an ecological conscience.

In the wildlife field, a parallel cleavage exists. For Group A the basic commodities are sport and meat; the yardsticks of production are ciphers of take in pheasants and trout. Artificial propagation is acceptable as a permanent as well as a temporary recourse – if its unit costs permit. Group B, on the other hand, worries about a whole series of biotic side issues. What is the cost in predators of producing a game crop? Should we have further recourse to exotics? How can management restore the shrinking species, like prairie grouse, already hopeless as shootable game? How can management restore the threatened ratites, like trumpeter swan and whooping crane? Can management principles be extended to wildflowers? Here again it is clear to me that we have the same A-B cleavage as in forestry.

In the larger field of agriculture I am less competent to speak, but there seem to be somewhat parallel cleavages. Scientific agriculture was actively developing before ecology was born, hence a slower penetration of ecological concepts might be expected. Moreover the farmer, by the very nature of his techniques, must modify the biota more radically than the forester or the wildlife manager. Nevertheless, there are many discontents in agriculture which seem to add up to a new vision of 'biotic farming'.

Perhaps the most important of these is the new evidence that poundage or tonnage is no measure of the food-value of farm crops; the products of fertile soil may be qualitatively as well as quantitatively superior. We can bolster poundage from depleted soils by pouring on imported fertility, but we are not necessarily bolstering food-value. The possible ultimate ramifications of this idea are so immense that I must leave their exposition to abler pens.

The discontent that labels itself 'organic farming', while bearing some of the earmarks of a cult, is nevertheless biotic in its direction, particularly in its insistence on the importance of soil flora and fauna.

The ecological fundamentals of agriculture are just as poorly known to the public as in other fields of land use. For example, few educated people realize that the marvellous advances in technique made during recent decades are improvements in the pump, rather than the well. Acre for acre, they have barely sufficed to offset the sinking level of fertility.

In all of these cleavages, we see repeated the same basic paradoxes: man the conqueror versus man the biotic citizen; science the sharpener of his sword versus science the searchlight on his universe; land the slave and servant versus land the collective organism. Robinson's injunction to Tristram may well be applied, at this juncture, to *Homo sapiens* as a species in geological time:

> Whether you will or not
> You are a King, Tristram, for you are one
> Of the time-tested few that leave the world,
> When they are gone, not the same place it was.
> Mark what you leave.

The Outlook

It is inconceivable to me that an ethical relation to land can exist without love, respect and admiration for land, and a high regard for its value. By value, I of course mean something far broader than mere economic value; I mean value in the philosophical sense.

Perhaps the most serious obstacle impeding the evolution of a land ethic is the fact that our educational and economic system is headed away from, rather than towards, an intense consciousness of land. Your true modern is separated from the land by many middlemen, and by innumerable physical gadgets. He has no vital relation to it; to him it is the space between cities on which crops grow. Turn him loose for a day on the land, and if the spot does not happen to be a golf links or a 'scenic' area, he is bored stiff. If crops could be raised by hydroponics instead of farming, it would suit him very well. Synthetic substitutes for wood, leather, wool and other natural land products suit him better than the originals. In short, land is something he has 'outgrown'.

Almost equally serious as an obstacle to a land ethic is the attitude of the farmer for whom the land is still an adversary, or a taskmaster that keeps him in slavery. Theoretically, the mechanization of farming ought to cut the farmer's chains, but whether it really does is debatable.

One of the requisites for an ecological comprehension of land is an understanding of ecology, and this is by no means co-extensive with 'education'; in fact, much higher education seems deliberately to avoid ecological concepts. An understanding of ecology does not necessarily originate in courses bearing ecological labels; it is quite as likely to be labelled geography, botany, agronomy, history or economics. This is as it should be, but whatever the label, ecological training is scarce.

The case for a land ethic would appear hopeless but for the minority which is in obvious revolt against these 'modern' trends.

The 'key-log' which must be moved to release the evolutionary process for an ethic is simply this: quit thinking about decent land use as solely an economic problem. Examine each question in terms of what is ethically and aesthetically right, as well as what is economically expedient. A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise.

It of course goes without saying that economic feasibility limits the tether of what can or cannot be done for land. It always has and it always will. The fallacy the economic determinists have tied around our collective neck, and which we now need to cast off, is the belief that economics determines *all* land use. This is simply not true. An innumerable host of actions and attitudes, comprising perhaps the bulk of all land relations, is determined by the land users' tastes and predilections, rather than by his purse. The bulk of all land relations hinges on investments of time, forethought, skill and faith rather than on investments of cash. As a land user thinketh, so is he.

I have purposely presented the land ethic as a product of social evolution because nothing so important as an ethic is ever 'written'. Only the most superficial student of history supposes that Moses 'wrote' the Decalogue; it evolved in the minds of a thinking community, and Moses wrote a tentative summary of it for a 'seminar'. I say tentative because evolution never stops.

The evolution of a land ethic is an intellectual as well as emotional process. Conservation is paved with good intentions which prove to be futile, or even dangerous, because they are devoid of critical understanding either of the land, or of economic land use. I think it is a truism that as the ethical frontier advances from the individual to the community, its intellectual content increases.

The mechanism of operation is the same for any ethic: social approbation for right actions: social disapproval for wrong actions.

By and large, our present problem is one of attitudes and implements. We are remodelling the Alhambra with a steam-shovel, and we are proud of our yardage. We shall hardly relinquish the shovel, which after all has many good points, but we are in need of gentler and more objective criteria for its successful use.

2

Four Principles of Natural Farming

Masanobu Fukuoka

Make your way carefully through these fields. Dragonflies and moths fly up in a flurry. Honeybees buzz from blossom to blossom. Part the leaves and you will see insects, spiders, frogs, lizards and many other small animals bustling about in the cool shade. Moles and earthworms burrow beneath the surface.

This is a balanced rice field ecosystem. Insect and plant communities maintain a stable relationship here. It is not uncommon for a plant disease to sweep through this area, leaving the crops in these fields unaffected.

And now look over at the neighbour's field for a moment. The weeds have all been wiped out by herbicides and cultivation. The soil animals and insects have been exterminated by poison. The soil has been burned clean of organic matter and microorganisms by chemical fertilizers. In the summer you see farmers at work in the fields, wearing gas masks and long rubber gloves. These rice fields, which have been farmed continuously for over 1500 years, have now been laid waste by the exploitive farming practices of a single generation.

Four Principles

The first is no cultivation, that is, no ploughing or turning of the soil. For centuries, farmers have assumed that the plough is essential for growing crops. However, non-cultivation is fundamental to natural farming. The Earth cultivates itself naturally by means of the penetration of plant roots and the activity of microorganisms, small animals and earthworms.

The second is no chemical fertilizer or prepared compost.[1] People interfere with nature, and, try as they may, they cannot heal the resulting wounds. Their careless farming practices drain the soil of essential nutrients and the result is yearly depletion of the land. If left to itself, the soil maintains its fertility naturally, in accordance with the orderly cycle of plant and animal life.

Reprinted from Masanobu Fukuoka. 1978. *One Straw Revolution: Four Principles of Natural Farming.* Other India Press and Rodale Press.

The third is no weeding by tillage or herbicides. Weeds play their part in building soil fertility and in balancing the biological community. As a fundamental principle, weeds should be controlled, not eliminated. Straw mulch, a ground cover of white clover interplanted with the crops, and temporary flooding provide effective weed control in my fields.

The fourth is no dependence on chemicals.[2] From the time that weak plants developed as a result of such unnatural practices as plowing and fertilizing, disease and insect imbalance became a great problem in agriculture. Nature, left alone, is in perfect balance. Harmful insects and plant diseases are always present, but do not occur in nature to an extent which requires the use of poisonous chemicals. The sensible approach to disease and insect control is to grow sturdy crops in a healthy environment.

Cultivation

When the soil is cultivated the natural environment is altered beyond recognition. The repercussions of such acts have caused the farmer nightmares for countless generations. For example, when a natural area is brought under the plough very strong weeds such as crabgrass and docks sometimes come to dominate the vegetation. When these weeds take hold, the farmer is faced with a nearly impossible task of weeding each year. Very often, the land is abandoned.

In coping with problems such as these, the only sensible approach is to discontinue the unnatural practices which have brought about the situation in the first place. The farmer also has a responsibility to repair the damage he has caused. Cultivation of the soil should be discontinued. If gentle measures such as spreading straw and sowing clover are practiced, instead of using man-made chemicals and machinery to wage a war of annihilation, then the environment will move back towards its natural balance and even troublesome weeds can be brought under control.

Fertilizer

I have been known, in chatting with soil-fertility experts, to ask, ‘If a field is left to itself, will the soil's fertility increase or will it become depleted?’ They usually pause and say something like, ‘Well, let's see… It'll become depleted. No, not when you remember that when rice is grown for a long time in the same field without fertilizer, the harvest settles at about 9 bushels (525 pounds) per quarter acre. The earth would become neither enriched nor depleted.’

These specialists are referring to a cultivated, flooded field. If nature is left to itself, fertility increases. Organic remains of plants and animals accumulate and are decomposed on the surface by bacteria and fungi. With the movement of rainwater, the nutrients are taken deep into the soil to become food for microorganisms, earthworms and other small animals. Plant roots reach to the lower soil strata and draw the nutrients back up to the surface.

If you want to get an idea of the natural fertility of the earth, take a walk to the wild mountainside sometime and look at the giant trees that grow without fertilizer and without cultivation. The fertility of nature, as it is, is beyond reach of the imagination.

Cut down the natural forest cover, plant Japanese red pine or cedar trees for a few generations, and the soil will become depleted and open to erosion. On the other hand, take a barren mountain with poor, red clay soil and plant pine or cedar with a ground cover of clover and alfalfa. As the green manure[3] enriches and softens the soil, weeds and bushes grow up below the trees, and a rich cycle of regeneration is begun. There are instances in which the top four inches of soil have become enriched in less than ten years.

For growing agricultural crops, also, the use of prepared fertilizer can be discontinued. For the most part, a permanent green manure cover and the return of all the straw and chaff to the soil will be sufficient. To provide animal manure to help decompose the straw, I used to let ducks loose in the fields. If they are introduced as ducklings while the seedlings are still young, the ducks will grow up together with the rice. Ten ducks will supply all the manure necessary for a quarter acre and will also help to control the weeds.

I did this for many years until the construction of a national highway made it impossible for the ducks to get across the road and back to the coop. Now I use a little chicken manure to help decompose the straw. In other areas ducks or other small grazing animals are still a practical possibility.

Adding too much fertilizer can lead to problems. One year, right after the rice transplanting, I contracted to rent 1¼ acres of freshly planted rice fields for a period of one year. I ran all the water out of the fields and proceeded without chemical fertilizer, applying only a small amount of chicken manure. Four of the fields developed normally. But in the fifth, no matter what I did, the rice plants came up too thickly and were attacked by blast disease. When I asked the owner about this, he said he had used the field over the winter as a dump for chicken manure.

Using straw, green manure and a little poultry manure, one can get high yields without adding compost or commercial fertilizer at all. For several decades now, I have been sitting back, observing nature's method of cultivation and fertilization. And while watching, I have been reaping bumper crops of vegetables, citrus, rice and winter grain as a gift, so to speak, from the natural fertility of the earth.

Coping with Weeds

Here are some key points to remember in dealing with weeds: As soon as cultivation is discontinued, the number of weeds decreases sharply. Also, the varieties of weeds in a given field will change.

If seeds are sown while the preceding crop is still ripening in the field, those seeds will germinate ahead of the weeds. Winter weeds sprout only after the rice has been harvested, but by that time the winter grain already has a head start. Summer weeds sprout right after the harvest of barley and rye, but the rice is already growing strongly. Timing the seeding in such a way that there is no interval between succeeding crops gives the grain a great advantage over the weeds.

Directly after the harvest, if the whole field is covered with straw, the germination of weeds is stopped short. White clover sowed with the grain as a ground cover also helps to keep weeds under control.

The usual way to deal with weeds is to cultivate the soil. But when you cultivate, seeds lying deep in the soil, which would never have germinated otherwise, are stirred up and given a chance to sprout. Furthermore, the quick-sprouting, fast-growing varieties are given the advantage under these conditions. So you might say that the farmer who tries to control weeds by cultivating the soil is, quite literally, sowing the seeds of his own misfortune.

'Pest' Control

Let us say that there are still some people who think that if chemicals are not used their fruit trees and field crops will wither before their very eyes. The fact of the matter is that by *using* these chemicals, people have unwittingly brought about the conditions in which this unfounded fear may become reality.

Recently Japanese red pines have been suffering severe damage from an outbreak of pine bark weevils. Foresters are now using helicopters in an attempt to stop the damage by aerial spraying. I do not deny that this is effective in the short run, but I know there must be another way.

Weevil blights, according to the latest research, are not a direct infestation, but follow upon the action of mediating nematodes. The nematodes breed within the trunk, block the transport of water and nutrients, and eventually cause the pine to wither and die. The ultimate cause, of course, is not yet clearly understood.

Nematodes feed on a fungus within the tree's trunk. Why did this fungus begin to spread so prolifically within the tree? Did the fungus begin to multiply after the nematode had already appeared? Or did the nematode appear because the fungus was already present? It boils down to a question of which came first, the fungus or the nematode?

Furthermore, there is another microbe about which very little is known, which always accompanies the fungus, and a virus toxic to the fungus. Effect following effect in every direction, the only thing that can be said with certainty is that the pine trees are withering in unusual numbers.

People cannot know what the true cause of the pine blight is, nor can they know the ultimate consequences of their 'remedy'. If the situation is meddled with unknowingly, that only sows the seeds for the next great catastrophe. No, I cannot rejoice in the knowledge that immediate damage from the weevil has been reduced by chemical spraying. Using agricultural chemicals is the most inept way to deal with problems such as these, and will only lead to greater problems in the future.

These four principles of natural farming (no cultivation, no chemical fertilizer or prepared compost, no weeding by tillage or herbicides and no dependence on chemicals) comply with the natural order and lead to the replenishment of nature's richness. All my fumblings have run along this line of thought. It is the heart of my method of growing vegetables, grain and citrus.

Notes

1 For fertilizer Mr Fukuoka grows a leguminous ground cover of white clover, returns the threshed straw to the fields, and adds a little poultry manure.

2 Mr Fukuoka grows his grain crops without chemicals of any kind. On some orchard trees he occasionally uses a machine oil emulsion for the control of insect scales. He uses no persistent or broad-spectrum poisons, and has no pesticide 'programme'.

3 Ground cover crops such as clover, vetch and alfalfa which condition and nourish the soil.

3

Knowing Systems and the Environment

Richard Bawden

Introduction

The logic behind the 'environmental concern' is seemingly impeccable, and evidence in its support, increasingly irrefutable. Through our activities as an ever-expanding and ubiquitous population of human beings, we are despoiling and degrading the environment of the world about us, while depleting it of its finite resources at an ever-increasing rate. This is not only threatening our own well-being and that of future generations of our own species, but also the stability and sustainability of particular biotic communities across the planet, as well as the integrity of the biosphere as a whole. The organization, functions and hierarchical organization of the long-evolved 'natural ecosystems' in which we are embedded as but one component species, are all now at very considerable risk. Such could be the level of the malignancy here that it could lead to a loss of hierarchical control across the entire 'systems-of-complex systems' by which 'nature' is seemingly organized, with the prospect of 'sudden and catastrophic failure' (Pattee, 1973) on an unimaginable scale. Ironically and tragically, much of this circumstance represents the unintended consequences of the developmental processes of modernization that we had come to claim as our greatest achievement as a species. This should dictate the need for a critical reappraisal of our whole techno-scientific, neoliberal approach to the idea of progress and 'betterment' and for us to be much more reflexive about how we should be living our lives in the context of the impacts that we are having on our environment (Beck, 1992).

The Conundrum

In the face of such a comprehensive and urgent challenge, it is difficult to reconcile our continuing acts of environmental despoliation with our competencies and dispositions as both rational beings and as the 'moral animals' that we claim to be (Wright, 1994). If we know that what we are doing is unsustainable in the long run, and that we ought not to be doing what we are doing, then why do we continue doing it? If, in all conscience, we appreciate that it is somehow ethically 'wrong' to behave in a manner that threatens the 'integrity, stability and beauty of the biotic community', as Leopold (1949) would assert, then why do we fail to heed our conscience and behave otherwise? And perhaps most significantly and irrationally of all, why, as knowledgeable and concerned citizens of the world, are we continuing to ignore the sensible call to 'learn our way out' of the mess that we ourselves are creating (Milbraith, 1989)?

The focus on learning here – on coming to know – is salutary: rather than planning our way forward under circumstances where, as convention has had it, we were confident of the end-state that we sought, we can only learn our way towards the adaptive management of the resilient systems that are key to sustainable futures (Holling and Gunderson, 2002). The very notion of what it is that we consider most worthy of being sustained in our lives, is, and will probably forever remain after all, quintessentially contestable (Davison, 2001). In essence, our quest to come to terms with sustainability and to design modes of development that lead to environmental sustainability must start with learning what each other means when we use those terms. As it is we, the citizenry, who are responsible for the mess that we now perceive we are making of the world about us, so it is up to us collectively to make-meaning through our learning as the basis for our collective judgements about what we now need to do. In other words, it is to social forms of learning that we need to now turn to inform the way by which, acting together, we should manage our environments within the context of sustainable futures (Keen et al, 2005). Social learning is central to the processes of the adaptive management (Holling, 1978) which we need to employ in order to reduce both uncertainties regarding matters of fact and disagreements about goals, objectives and values that can all affect management decisions with respect to the search for sustainability (Norton, 2005). A key complication here is that *what* each individual comes to know, through learning, is very much a function of *how* he or she comes to know, and this makes the search for communal meaning and thus consensual judgment singularly difficult (Maturana and Varela, 1987). And this is then further compounded by the communication limitations imposed by language (Norton, 2005) and even more fundamentally by the apparent 'taboo' of Western culture that 'tells us it is forbidden to know about knowing' (Maturana and Varela, 1987).

While it is our reluctance and/or our lack of capability to engage in social learning or even to recognize its significance that arguably pose the greatest impediments to our current dilemma, other factors also clearly contribute.

There is, for instance, the issue of the priorities that we set for ourselves, to say nothing of our denial of the circumstances on the one hand, and of our addiction to our current ways of life and the resources that we need to support these, on the other (Griffiths, 2003). It is indeed as difficult to concentrate on the global greenhouse gas emissions when one is trying to keep warm in a North American winter or has to drive to the shops in the mall or to the school in the suburbs or to church on the Sabbath, as it is to be concerned with the integrity of the proverbial swamp under the duress of fighting off the equally proverbial alligators. As the human population moves inexorably towards the ten billion mark, and upwards, it is sufficiently difficult to see how the quest for ever-increasing production of food can be sustained for instance, or how the growing demand for energy resources can be met in a rapidly 'globalizing' and modernizing world, without also having to worry about sustaining the environment writ large into an indeterminate future.

We are also victims of the priorities that are set for us by others who have their own motives and motivations for so doing, be that short-term economic gain or political expedience or the machinations of the cultural politics in which environmental discourse is now conducted (Hajer, 1996).

Then there is the matter of the abdication, by us as a civil society, of our responsibilities for public judgement through our deferment, in decisions regarding the public good (Giddens, 1979), to the expertise of the scientists, economists and the policy makers, and to the officers and institutions of governance. After all, a perfectly rational defence for this can be raised with respect to what Fuller (1991) refers to as 'cognitive authoritarianism' where the rationality of thinking for oneself 'diminishes as the knowledge-gathering activities of society expand to the point of requiring the division of cognitive labour into autonomous expertises'. The clear downsides of this phenomenon, however, relate both to the eventual loss of the capacity of humans to participate in any discussions and decisions about the ways by which we should live our lives through sheer lack of practice (Yankelovich, 1991) and to the essential hegemony that an instrumental technical rationality has come to assume over other rationalities, especially in 'developed' capitalist societies where questions of 'how' have come to supersede those of 'why' (Habermas, 1979). These two latter positions echo the equally somber view of Toffler (1984) that the 'political technology' that has emerged along with modernization has not been particularly adaptive, leading instead to 'a mismatch between our decisional technology and the decisional environment' that has been characterized by 'a cacophonous confusion, countless self-canceling decisions, noise, fury, and gross ineptitude'. Under these circumstances it is difficult to disagree with Dietz and his colleagues that devising ways to 'sustain the earth's ability to support diverse life, including a reasonable quality of life for humans, involves making tough decisions under uncertainty, complexity, and substantial biophysical constraints as well as conflicting human values and interests' (Dietz et al, 2003).

It is this claim that provides a clue to perhaps the most significant answer to questions about our seeming lack of commitment to 'learning our way out' of the enduring, self-inflicted crisis of our relationships with the world about us. While environmental scientists, systems ecologists, social ecologists, economists, sociologists and other 'experts' have indeed come to know a very significant amount about 'natural' and 'social systems' 'out there', as a civil society we still know very little about how we can collectively come to make knowledgeable decisions and judgements about what we need to do to change the way we live our everyday lives. In focusing so attentively on knowing *systems* 'out there' we scientists have come to ignore the nature, significance and development of the *knowing* systems by which they can become known to us all and can be collectively and sustainably managed. We have also managed to alienate a significant proportion of our fellow citizens through their perceptions of the epistemic limitations of our own learning systems (though they would probably not phrase it exactly in those terms) and our unwillingness to either appreciate or to accommodate other systems of knowing (Leach et al, 2005).

The introduction of the idea of 'system' here is deliberate and timely, for the systems idea will be the cognitive principle around which the arguments that follow, will be organized.

The Systems Idea

It is difficult these days to browse any article or book about the science, management or politics of the environment that is free of any explicit reference to 'systems' or 'systemics' or, at least, implicit embrace of 'holism' as an essential perspective. These range in their scale of reference from expositions of the panarchy theory of *ecosystem* organization (Gunderson and Holling, 2002) through the significance of *knowledge systems* for sustainable development (Cash et al, 2003) to the characteristics of emerging sciences themselves as with *systems* ecology and, most recently perhaps, in *systems biology* (Kitano, 2002). The ideas that unite these disparate endeavours include wholeness, comprehensiveness, interconnectedness, embeddedness and emergence.

In this manner, environmental science well exemplifies the claim of Ackoff (1974) that 'the systems age' has come to replace 'the machine age' of the industrial revolution, with holism coming to challenge the previously dominant epistemologies of 'reductionism' and 'positivism' of pre-systemic science. As Jackson (2000) has argued, this new-age dawning is a response to the 'complexity and turbulence' that we are all experiencing in our everyday lives, as well as by the additional confusion brought by the 'multiplicity of viewpoints about the direction we should be taking' and by the multitude of concerns about how we should be handling the difficulties that we face. The adoption of systems (= systemic) perspectives allows a cognitive coherence to be brought to bear on our considerations of these circumstances.

All acts of cognition start with a distinction between a thing (or a being or an entity) and its background or its environment, and each time we explicitly refer to anything, therefore we specify 'a criterion of distinction' which indicates what we are talking about (Maturana and Varela, 1987). Cognition thus depends on our abilities to distinguish between an 'it' and the 'other'. In its simplest formulation then, the systems idea makes the distinction between the system as a coherent bounded entity (the 'it') and the environment (the 'other') from which it can be distinguished, but with which is structurally coupled through recurrent interactions between the two (Maturana and Varela, 1987). Therefore the unit of interest of the systemist – where systemists are to systems as economists are to economies – is both the 'it' and the 'other' as well as the relationships between the two. In fact, systemists typically think in three 'it/other' dimensions – the part (subsystem), the whole (the system of interest), and the higher order whole (the environmental supra-system of the system) of which the system is itself a subsystem – plus all the sets of interactions within and between these three levels. The significance of this 'tri-hierarchical' or 'holarchical' conceptual organization of systems-of-systems lies with the belief that at each 'level', surprisingly novel properties, that are unique to that level, emerge as a function of the interrelationships between its component subsystems and the environment that its higher order system presents to them. The fundamental assumption of 'holism' therefore, is that no system can be known, nor its total characteristics nor properties predicted, through a study of any of its component subsystems in isolation from each other or from the system itself: an assumption that is in direct opposition to the basic premise of reductionism.

The systems idea is far from new within the natural sciences of course. Indeed while an appreciation of the significance of what might be termed an 'essence of wholeness' seems to pervade a wide range of 'indigenous cultures' and can be associated with an intellectual heritage from ancient Greece, most especially through the insights of Aristotle (Russell, 1961), some of the earliest formalizations of thinking in 'systems terms' can be found among scientists writing about biological phenomena and the 'nature of nature'. Smuts (1926), for instance, was the first to formally write about 'holism' – which he defined as 'the tendency in nature to produce wholes' – and of the significance of that to 'the internal organization' of organisms and to the evolution of their species. In the same era, Woodger (1929) further extended these ideas through his emphasis on the hierarchical nature of organization within organisms, while both Canon (1932) and Henderson (1941) reflected on the significance of the capacities of organisms as 'living systems' to adapt in order to maintain their own integrity in the face of challenges from the turbulent environments in which they had to exist.

Perhaps the most influential biologist with respect to the application of the systems idea to biology, however, was von Bertalanffy who took some of the key concepts of these early pioneers and further extended them into the formulation of what he eventually referred to as a General Systems Theory (GST) (von Bertalanffy, 1968). Earlier, he had made the vital distinction between 'closed' and 'open' systems (von Bertalanffy, 1950) with regard to their respective relationships with their environments. Central features of the 'open systems' of von Bertalanffy included the need for 'cybernetic regulative processes' that were essential for maintaining their 'steady state equilibria'. Tellingly, the concept of the 'ecosystem', as it was introduced by Tansley (1935), was a much looser notion of a 'living system' than that developed by von Bertalanffy and his 'systems' predecessors, referring, as it did, to a relatively unbounded set of structural and functional relationships between a biotic community and some circumscribed abiotic features. The integrity of such a system was held to be maintained in a state of equilibrium through the flows of energy and matter between its parts. This key focus on the structural and functional nature of ecosystems in equilibrium was later replaced by the more cybernetic notions of dynamic equilibria and steady states (Patten, 1959) in which a much clearer distinction was made between the ecosystem and its environment. Other vital concepts that this view of functional organizational integrity permitted was the possibility of the adaptation of the whole ecosystem with respect to changes in its environment as well as its evolution as a whole entity as a function of changes in the diversity both of its parts and of the pattern of interrelationships between them. Thus while it became possible to talk sensibly of both stability and resilience of ecosystems as prerequisite properties for adaptation in turbulent environments (Holling, 1973), it also made sense to talk of their capacity to evolve as whole, integrated entities, even in the absence of any clear empirical evidence that this indeed did occur in actuality.

While having adaptive capabilities of this type, such self-organizing systems are generally regarded as being very complex in their organization and in the spectrum of their interrelationships with the environments in which they are embedded and with which they interact. They can be so complex and dynamic in fact, that they can 'move' or be forced to positions that are far from equilibrium (Gleik, 1987), in which state they are regarded as being on the 'edge of chaos' where a small change in one component of the system can result in greatly amplified reactions elsewhere in the system. This can lead either to the demise of such systems or to the emergence of totally different systems (Stacey, 1996). Of even greater significance in this context, is the possibility, promoted by hierarchy and panarchy theorists, that entire hierarchies of systems can be affected under conditions where the complexity of any system within them becomes so great that it overwhelms existing controls across the entire hierarchy (Levins, 1973) with potentially disastrous results. Importantly it has been claimed that these 'natural' phenomena have potentially as much significance to hierarchies of human organizations and 'social systems' as they do for the ecosystems and hierarchies of nature (Wheatley, 1992). Indeed it was an economist who was to add considerable rigour to GST with his conceptualization of a nine-level hierarchical typology of complexity (Boulding, 1956), that ranged from static structures and frameworks that can be studied, through to transcendental systems which are the realm of 'inescapable unknowables'. Boulding's other considerable contribution was to argue that GST could be used for ordering different fields of study through a focus on the 'individual unit of behavior' in addition to its aim of developing a theory of very general principles, which, as Jackson (2000) observes, was the primary concern of von Bertalanffy.

The key feature of a general systems theory which allows this submission is the principle of isomorphism from which many have been able to conclude that what is so for 'natural systems' must be equally so for 'social systems'. And thus all that has been written above with regard to the nature and behavioral characteristics of living systems has been transposed in one form or another over the years, to apply to the nature and dynamics of human organizations and societies: these are, as the logic goes, composed of human beings which are, in turn, 'living systems' and much effort has been put into the application of systems approaches to human affairs over many decades past, in the search for knowledge about the nature of 'human systems'. This has a particular relevance to this present context of an environmental challenge that dictates the need to come to know and understand what is claimed to be 'the fundamental character of interactions between nature and society' (Kates et al, 2001). This is a challenge that accepts that the governance of ecosystems as complex adaptive systems requires flexibility and cognitive capacities for knowing and learning in response to 'environmental feedback' (Levin, 1998).

For all of these efforts, however, and for all of the apparent success of the system's focus in ecology, in environmental science and as a feature of the emerging sustainability sciences (Kates et al, 2001) and systems biology (Kitano, 2002), the systems idea and the styles of systems thinking that it promotes, has actually found declining support within the social sciences. As one of its most astute observers posits, systems thinking was in a less secure position within the social sciences at the beginning of the 21st century, than it had occupied several decades earlier (Jackson, 2000) at the time that the 'dawn of the systems age' had been acclaimed by Ackoff (1974). This represented a significant change from the situation where systems perspectives on, and systems approaches to the analysis of, social groupings had really been the dominant paradigm within sociology at least, and most especially among those concerned with organizational management and development.

While host of reasons can be cited for this situation – and Jackson (2000) indeed articulates most of the major influences, from the novelty of changing paradigmatic perspectives that range from functionalist through interpretivist and emancipatory to postmodernist – a central distinction between 'natural systems' and their 'social system' analogues is the inherent reflexivity of human beings (Westley et al, 2002) and our critical capacities for knowing, and for changing our minds and the views that we hold of the world about us.

As it happens, Ackoff would have been more accurate to have claimed in the mid-1970s that this was the dawning of a 'new systems age', or the emergence of a 'second wave of systems thinking', as Midgely (2000) describes it, which was being characterized by a very significant change of mind about 'systems' themselves and systemics, among, at least some, systemists. And this observation provides a useful segue into the next section of this chapter where the focus changes from a consideration of 'systems in the world' to the 'systems of cognition' through which we come to know that world. In essence, in now changing the emphasis from knowing *systems* as it were, to *knowing* systems, we reflect what Checkland (1981) referred to with his introduction of the soft systems methodology as 'the shift in systemicity from the world to ways of inquiry into that world' which indeed represented the character of the dawning of the 'new systems age' to which he himself has been such a dominant contributor.

Knowing Systems

A useful way of exploring the notion, nature, development and significance of 'knowing systems' is to reprise the earlier concept of three-dimensional thinking, specifically through the introduction and exploration of the three-level model of cognitive processing developed by Kitchener (1983) in which she suggested that different 'levels of processing' allow individuals to monitor one level of cognitive tasks at another level. She distinguishes between cognition (or level one), meta-cognition (level two) and epistemic cognition (level three) as a hierarchical sequence through which individuals can monitor the way by which they conduct their own basic cognitive tasks through a meta-cognitive process, which is itself monitored by a process of epistemic cognition. Applying a system's logic to this model, and expressing it in terms of knowing, it is thus possible to claim that a knowing or learning system can be seen to intrinsically comprise: (i) a cognitive (sub)system, which deals with the process of coming to know about the matter to hand; (ii) a meta-cognitive system that deals with the process by which the matter to hand is, and can be known; and (iii) the epistemic-cognitive (supra-)system that deals with the epistemological limits to what can be known about the other two levels as circumscribed by the very nature of knowledge itself. Conceived in this manner, each level in this intrinsic 'system-of-systems' is profoundly interconnected with the others, with each essentially providing the contextual environment for the others. The epistemic supra-system, furthermore, can be expanded to embrace not just epistemological aspects of knowing and knowledge, but also of ontological assumptions about reality and the nature of being, and about axiological assumptions and beliefs that are expressed as values. In this manner, the essential focus of the epistemic (supra-)system are the cognitive frameworks or 'meaning perspectives' or *Weltanschauungen* that represent 'those usually taken-for-granted and often idiosyncratic values, norms, and beliefs that constitute our individual and socialized views of the world' (Plas, 1986). As Kuhn (1962) presented them, such worldviews become paradigms when, as 'entire constellations of beliefs, values, techniques and so on' they are shared and put into practice by given communities. And this emphasis on 'practice' adds the fourth element of 'methodology' to the episteme where it represents the way through which the other three are interpreted into action. Thus where method, as the process of knowing, is the focus of meta-cognitive inquiry and evaluation, then methodology, as the expression of epistemological, ontological and axiological assumptions in practice, is the focus for epistemic-cognitive inquiry.

From this perspective then, it is entirely appropriate to claim that the emergence of the 'second wave of systems thinking' and the introduction of profound distinctions between the previous 'hard' systems thinkers and the new 'soft' systems types was indeed equivalent to the introduction of a new paradigm of systemics. In this light, it is perfectly understandable, as Kuhn himself would have predicted, that the shift would be associated with very significant controversy equivalent to an 'open intellectual warfare' which not only regrettably continues to this day, but has been further compounded by the subsequent introduction of a third 'critical' wave (Midgley, 2000) which focuses attention essentially on to judgements to do with social (and environmental) conditions, with the placement of boundaries and with reflexivity in knowing. These three 'waves' differ very profoundly from each other in their epistemic assumptions about the nature of nature, the nature of knowledge and the nature of human nature. Ideas from all three waves or schools of systems thinking will be significant in the conceptualization of the critical knowing/learning systems with which this chapter concludes.

The epistemic position adopted by the General Systems Theorists and by a generation of systems practitioners who were significantly influenced by them (including many systems ecologists, simulation modellers, ecosystem and systems biologists, and environmental scientists), was of the 'hard school'. From this dualistic perspective, nature 'really' is organized in the form of coherent 'systems' of integrated parts that, in turn, 'really' are organized as nested system hierarchies. In this regard it is also interesting to note the definition of a human community offered by Flora et al (1992) as 'a place and *a human system*', the claim by Daley and Netting (1994) that 'communities are living entities … (that) … like people, go through a normal life cycle', and their call for 'understanding complex social systems' as a vital reason for introducing 'systems thinking' into community development (Daley and Netting, 1994).

Such ontological realism leads, almost inevitably, to the adoption of positivist and objectivist epistemological positions: observed systems are considered to be independent of those doing the observations while the knowledge that is gained through this positivist process is considered to be objective in the sense that there must be some 'permanent or ahistoric matrix or framework' to which appeal may be ultimately made 'in determining the nature of rationality, knowledge, truth, reality, goodness or rightness' (Bernstein, 1983). Moreover, because the hard systems approach was, by definition, held to be value-free, there was little that could sensibly be known or said about what ought to be done under circumstances where the indications were that something needed to be done (which, ironically enough, was itself was a normative judgement, of course). The issue of judgement became a key criterion of distinction for Vickers (1983) in his contention that human systems were so different that it was just not possible to study them using the logic and methods of the natural sciences, precisely because of the significance of judgement to human beings. His introduction of the notion of 'appreciative systems' – those sets of largely tacit standards of judgement by which we both order and value our experiences – as unique to 'human systems' dictated that they depended on shared understandings and shared cultural mores if they were to be effective and stable. A key feature of 'second wave' systemic thinking relates to the significance of human judgement to the placement, as it were, of systems boundaries (Midgley, 2000). This is in direct contrast to the 'boundaries as given' notion that prevailed within the 'hard school', and that persisted even when the concept was extended beyond the obvious – such as with the extension of the systems idea beyond obviously bounded individual cells and organs and organisms to include the much less evidently bounded 'ecosystems' in the form of the higher order 'biotic communities', as introduced by Tansley (1935).

These issues are far from trivial for they get to the very heart of the conundrum of why it is that the citizenry seems so reluctant to commit itself to learning its way out of the environmental mess that, paradoxically, many willingly acknowledge needs to happen. They also highlight some of the critical deficiencies of the environmental and ecological 'knowing systems' that are contributing to this paradox. Witness for instance, the long-standing ambivalence of ecologists with regard to the ontological status of human beings with respect to 'natural ecosystems', which does little to inspire the confidence of the citizenry. As Berkes (1999) has stated with such eloquence, within ecology, human beings are so frequently regarded either as somehow 'un-natural' components of 'natural eco-systems' or are placed into such mythological categories as the 'Ecologically Noble Savage', the 'Intruding Wastral', or the 'Fallen Angel'. To this, as has been already indicated, must be added the issue of the ontological status and organization of 'nature itself' and whether the notion of ecosystems as cybernetically regulated, stability-seeking entities that can evolve in all of their wholeness, can ever be empirically validated beyond mathematical representation. And what a sloppy concept 'nature' turns out to be under such circumstances, and 'society' too for that matter, and yet vocal is the claim that the new field of sustainability science for instance, 'seeks to understand the fundamental character of interactions between nature and society' (Kates et al, 2001).

The environmental sciences meanwhile have an even more difficult epistemic issue with which to contend, for in identifying the environment as their issue of concern, they are in fact nominating the 'other' as their 'it'. This creates a further source of epistemic confusion, for if the 'other' becomes the 'it' in any act of cognition, then the question arises of what now is the 'other' and what is the significance of the interrelationships between 'it' and whatever the 'other' is deemed to be? As well as being a matter of some epistemic significance to environmental scientists, this matter is also central to the contributions of environmental philosophers in their attempts to bring synthesis to what Belshaw (2001) has highlighted as 'reason, nature and human concern'. This focus well captures the claim that the quest for environmental sustainability must not only embrace what it is that could persist over time, but also, and essentially, what it is that should be allowed to persist (Thompson, 2004). It also illustrates a basic contention of Norton (2005) of what is needed if we are to intelligently discuss and learn about our environmental goals and how to achieve them: we will need a discourse which is rich enough to express and disagree about values – which perforce must include aesthetic notions of beauty as well as ethics – while also incorporating knowledge gained through scientific understanding. And all of this, as Norton particularly insists, demands communicative and cooperative behaviour of us within our communities in ways that allows clarification of epistemological and ethical assumptions as well as accommodating processes by which these can be safely challenged and, when appropriate, changed. As Grove-White (1996) has asserted, modern environmentalism has evolved 'not simply in response to damaging impacts of specific industrial and social practices, but also, more fundamentally as a social expression of cultural tensions surrounding the underlying ontologies and epistemologies which have led to such trajectories in modern societies'.

Such is the nature and focus of epistemic cognition; its importance returns our gaze to the concept of the 'knowing system' and a further application to it of the systemic principle of 'three dimensionality' with the suggestion that the *knowing system* be regarded as an integral subsystem of every system under consideration along with the environmental supra-system in which that, in turn, is embedded. This fresh 'three-dimensional' view is consistent with the emphasis in the hierarchy theory as being propounded by Ahl and Allen (1996) that the observers (knowers) need to be 'reunited' with the observed for it is they who are indeed responsible for recognizing boundaries around entities as well as proposing the criteria for making those distinctions. It is these 'knowers cum decision makers' who must make the judgements about who is to be included within the system of concern, what sort of knowledge will be needed and who can be relied upon to generate it, who it that should be the main beneficiaries of any indicated change, and who will speak for those unable to be present (Ulrich, 1983). In this view, systems are indeed in the eye of the beholder, as Checkland (1981) has asserted: they are abstract constructions of a concrete reality that cannot be directly accessed through the senses, or of a coherent set of processes for collective learning within a community of interest about what might be done to improve situations that they experience and appreciate as problematic to them in one form or another (and perhaps also to others). These perspectives, it is submitted here, are of profound significance to environmental concerns, and represent crucial ways by which these concerns can become known and can provide intelligible, trustworthy and collectively generated knowledge about both what *could* be done in the search for environmental sustainability and what *ought* to be done. In essence these demand different ways of knowing and reasoning and thus different rationalities, as Habermas (1984) has long insisted. Thus while his 'instrumental rationality' is entirely appropriate for exploring the 'external natural world', it needs to be replaced by 'communicative action' whenever and wherever the purpose is 'mutual understanding to realize common goals and values' (Yankelovich, 1991). These will demand access to epistemic cognition for their clarification.

With its own three-dimensional capacities for cognitive processing, the 'knowing system' as now envisaged, brings a learning and critically reflexive capacity as a subsystem to any system or systemically appreciated situation in which it embeds itself. As mentioned earlier, it draws on elements of all three waves of systems of thinking: it can consist of a tangible group of people (a 'hard' systems perspective) who commit themselves to behaving as if they were a coherent 'knowing system'. They will have a clear idea of the matters to hand that they are addressing, an unambiguous understanding of the systemic processes of knowing that they employ (a 'soft' systems perspective), and an inherent appreciation of the need to bring critical reflections (a 'critical' systems perspective) to all of these matters as well as to the epistemic aspects of all that, as a knowing system, it is trying to accomplish. Through their interconnectedness, each individual within the 'knowing (sub)system', will contribute to the collective process of knowing, to the knowledge that comes to be known, and to the democratic deliberations that are an essential property of that system. Each person learns with and through all of the others.

To behave effectively in this manner, knowing (sub)systems must have capabilities at all three levels of cognition, and must be prepared to allow for their own evolution as a knowing system as evidenced by collective intellectual and moral development. This last issue is of signal importance, for as Salner (1986) has emphasized, there is a strong correlation between the capability to think in any systemic way – and thus effectively use any systems methodology – and an advanced state of epistemic development. Drawing especially on the work of both Perry (1968) and Kitchener (1983), Salner argues that it is essentially not until one has learned the characteristics of an epistemological/ethical stance of what Perry referred to as 'contextual relativism' or 'contextualism' and has developed on from 'dualism', that one is able to develop effective systemic competencies. Addressing complex issues with any success, demands the development of complex meaning perspectives or worldviews (West, 2004), and that, in turn, demands critical attention. It is from a similar position that Bawden (2000, 2005) has made the claim that sustainable acts of development in the material and social worlds are functions of the intellectual and moral development of all of those who ought to be involved in those acts. This therefore brings a fresh, critical epistemic perspective to the calls for social learning as the foundations for the adaptive management of 'the environment', made by Keen et al (2005), and to support the quest for shared goals for sustainability and policies for greater environmental protection through public discourse which is 'holistic' in both its focus and its nature (Norton, 2005). As Norton readily concedes, the adoption of 'holistic adaptive management' as a social learning approach to environmental sustainability, presents a host of philosophical as well as practical challenges to all concerned, with the need for ethical, aesthetic, ontological and epistemological considerations to be taken seriously if we are ever to come to really know what to do better with respect to our relationships with the environment about us (Norton, 2003) – which represents 'the matter to hand', in the language of 'knowing systems'.

This perspective on social learning for adaptive management indicates the need for what is referred to as 'transformational learning' (Mezirow, 1991) that involves epistemological challenge and change, in contrast to 'informational learning' which is merely 'a change in behavioral repertoire or an increase in the quantity or fund of knowledge' (Kegan, 2000). A key distinction between the outcomes of these two forms of learning lies with their differential impact on the 'frames of reference or minds' that we use in structuring our knowing. Thus, as Kegan sees it, both kinds of learning are expansive and valuable, 'one within a preexisting frame of mind and the other reconstructing that very frame' or worldview: from the perspective of the three-dimensional knowing (sub)system being promoted here, this focus on 'changing frames' or – 'meaning perspectives' as Mezirow (1991) calls them – is directly analogous to the concept of 'epistemic development'.

It is perhaps most useful to conclude this piece with a brief reference to the meta-cognitive competencies – the learning how to learn and knowing how to know – that remain to be addressed here. In patent contrast to those who see learning as the acquisition of knowledge, Kolb (1984) presents it as 'the process by which knowledge is created through the *transformation* of experience'. From this experiential perspective, knowledge is continuously being created, recreated and 'used' by individuals as they seek to make conceptual sense of what they are sensing through their own experiences of the ever-changing 'concrete' world about them, as the essential prelude to taking sensible actions to adapt, or to adapt to, that perceived reality.

As Kolb sees it, it this adaptation that is the essential motivation for coming to know and learning: indeed, as he argues, 'learning is *the* major process of human adaptation' (Kolb, 1984, p32). Echoing one of the central themes of this chapter, Kolb insists that experiential learning is a 'holistic process' that involves constant transactions 'between the person and the environment' in a manner that engages 'the integrated function of the total organism – thinking, feeling, perceiving and behaving'.

But with that insistence, of course, Kolb reveals an epistemic position as well as a systemic orientation and logic, that is far removed from the dualism and reductionism that continues to prevail, ironically enough, within our formal institutions of learning and in our conventional knowing institutions which 'extract' the perceptual/sensual from the conceptual, and action from reflection, the subjective from the objective and so on. This Kolbian view of learning is as a quintessentially participative and transformative process in which the transformative power lies with both 'the whole' knowing system and 'its parts'.

Knowers develop a deep sense of the world that they are experiencing from the perspective of being 'embedded' within it and participating as part of it, even as they are trying to make sense out of it. Thus participation is an 'implicit aspect of wholeness', as Skowlimowski (1985) claims, which, in this learning/knowing sense includes, as Bohm (1987) emphasized, 'thoughts, "felts" and feelings' as well the 'state of the body'. Importantly, as Bohm also argued, it is a social process with 'thought passing back and forth between people in a process by which thought has evolved from ancient times'. This continuous 'unfolding' and 'enfolding' of meanings, thoughts, 'felts' and even intentions and 'urges to do things', cannot be anything other than a dynamic, systemic process of individuals and social groupings alike – and indeed of the mind itself. And all of this is very reminiscent of Goethe's participatory approach to a science through which he strove 'to enliven and deepen our understanding of nature' (Barnes, 2000). The Goethean scientist, claimed Bortoft (1996), 'does not lose himself or herself in nature, but finds nature within himself/herself in fully conscious experience'. Such conscious participation, is seen as a synergistic condition in which humanity and nature work together in such a way that 'each becomes more fully itself through the other'; a mutual enhancement.

A similar claim has been made for the synergy between the 'experiential knowing' processes of Kolb (as a subsystem) and what has been called 'inspirational knowing' by Bawden (1998); where the former refers to the transformation of experience into knowledge, inspirational knowing accesses 'innate insights' as its focus for transformation. It can be postulated that it is through inspirational knowing that we come to know our positions on 'rights' and 'virtues' and 'aesthetics' which are then synergistic with our experientially derived contexts and instrumental knowledge of the world, which we bring to bear in our communicative actions with others, to change our ways with it!

And all of this occurs within a learning (sub)system which has an internal ambience of emotions and dispositions that are embraced as essential to the transformative functions of that system.

Conclusion

As the above has indicated, a fourth, vital category can, and ought to be added to Berkes' (1999) typology: to the 'Ecologically Noble Savage', the 'Intruding Wastral' and the 'Fallen Angel' can/ought now be included the intrinsically three-dimensional 'Knowing Being'. Through their cognitive competencies, humans are capable of coming to know about matters to hand that concern them, coming to know how they come to know that, and coming to know the epistemic contexts in which these two 'lower order' processes operate (Kitchener, 1983). Such a knowing system can refer both to individuals and to social collectives of individuals. In functional terms, the 'triarchical' organization of this intrinsic human knowing system allows cognitive (level one) processing, meta-cognitive (level two) processing, and epistemic-cognitive (level three) processing to proceed in a synergistically interconnected manner. The epistemic dimension embraces all three of the essential 'elements' of human worldviews and paradigms – epistemology, ontology and axiology.

A key conceptual implication of the knowing system is the adaptation of the lower order systems to changes in the epistemic supra-system, which, it is suggested, tends to evolve (or be deliberately developed) from the relative simplicity of 'dualism' to the much more complex 'contextualism'. The paradox here, or at least the enigma, is that until and unless the knowing system evolves or is developed to this position, it cannot appreciate its own systemic nature (Salner, 1986).

The systems image can be further extended to present this intrinsically three-dimensional 'knowing system' as the key subsystem within an extrinsic, three-dimensional system-of-systems. A knowing (sub)system attempts to make sense out of what it senses in both 'the system' which it construes or 'brings forth' (Maturana and Varela, 1988) and of which it sees itself as an essential component part, and the environmental supra-system in which that system is construed to operate, and with which it is 'structurally coupled' (Maturana and Varela, 1988). In this manner it is possible to understand and present the 'environmental concern' as either a concern of the state of the immediate system, or of the environmental supra-system at large – but, and most significantly, only when that knowing (sub) system reaches an epistemic state that supports such a construction!

Therein lies the challenge of engagement with the quest for environmental sustainability and for the design of systems that are appropriately stable, resilient and influential to that end. Therein also lies the foundations for the provocative claim that all systemic acts of sustainable development in the material and social worlds are quintessentially functions of the epistemic development of those actors who need to critically engage with the issue. And the source of the provocative claim that all acts of development in the context of systemic sustainability will depend on the systemic appreciation (and thus epistemic development) of all of those who need to act in those circumstances.

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4

Agricultural Sustainability: What It Is and What It Is Not

Paul B. Thompson

Philosophers spend a large part of their time scrutinizing words and concepts, attempting to get clear on what they mean, and on the implications of their meaning for human endeavours. Philosophical analysis of words and concepts yields a more explicit statement of assumptions that are generally taken for granted when people speak in a certain way. Analysis can reveal ambiguity that leads to confusion and miscommunication, and it can provide insight in how interpreting a concept in one way or another can lead to large and systematic differences in the way that two people using a single vocabulary approach a given topic. Programmes in sustainable agriculture apply human, biological and financial resources to the development of technology and social institutions. They generally draw upon agronomy and other agricultural sciences to research and disseminate tools and techniques that farmers can use, or they draw on the applied social sciences to support decision making and social organization to meet the local problems of rural communities. Philosophy is a very abstract activity, and sustainable agriculture a very concrete activity. What can they have to do with one another?

There are at least two points of contact. The presumptuous title of this paper is intended to convey the idea that philosophical debate over the meaning of sustainable agriculture will prove to be a useful and important exercise. Sustainable agriculture programmes are constantly subjected to criticism and debate about what, precisely, they should be doing. Some believe that resources should be allocated to agronomic techniques characterized by reduced chemical use or low inputs. Some believe that resources should be allocated to programmes that make farms of a certain scale or pattern of land use more profitable. Still others believe that conventional agriculture is just fine as it is, and that there is no need or basis for special programmes on 'sustainable' agriculture. Each of these viewpoints involves a different perspective on what it means for a farm, a production system or a more comprehensive food system to be sustainable. The variety of views on what it

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means to be sustainable has multiplied since the early 1980s, when critics of conventional agriculture began to claim that it was 'unsustainable'. The debate is no longer confined to agriculture. Others now want to talk about 'sustainable development', 'sustainable land use', and even 'sustainable architecture'. Yet few that participate in these debates have the time, inclination or skills to step back and analyse whether what separates them is a difference in values and perspectives, or a simple verbal dispute.

Philosophy can at least help clarify what is being disputed, even if it cannot resolve the dispute. It is possible that the philosopher's task will end when the terms of debate have been clarified. Yet I think that sustainability will turn out to be a contested concept of more enduring and fundamental interest. In some cases, our thinking and communication can be clarified simply by attending closely to a specific definition. Other times we find that a particular concept is so important to the way we understand ourselves and our world that we cannot gain mastery over it simply by specifying a definition for a given context. Concepts like 'truth', 'objectivity', 'causality', and 'justice' have been contested throughout human history. Such concepts have resisted our attempts to specify them in any final sense, yet it seems we must use these concepts to think at all. I believe that as we come to think more deeply and carefully about the impact of human activity on the broader environment and on the opportunities of future generations, we will find that our conceptions of sustainability have a tremendous impact on the way that we frame these problems. So philosophy encounters sustainable agriculture first by offering tools to better understand disputed visions of what sustainable agriculture might involve, and second because the debate over sustainable agriculture may well be the opening to an important new area for environmental ethics.

Encountering Sustainability

Philosophers generally began to take an interest in the concept of sustainability in the late 1980s, and I have been working on it myself for almost 20 years. My thinking on sustainability has two main phases. From about 1988 until about 1994, I was fairly sceptical and even cynical about the idea of sustainability. This is not to say that I was ever opposed to sustainable agriculture, for I was not. However, for about six years I believed that the debates over sustainable agriculture and sustainable development were driven by different conceptions of social justice, at best, and underlying economic interests at worst. Big fertilizer, seed and equipment firms thought that sustainability meant continued profitability for big fertilizer, seed and equipment firms, small farmers in Nebraska thought that sustainability means being able to continue farming at a small scale in Nebraska, advocates for Latin American peasants thought that sustainability meant social justice for Latin American peasants etc. My writing from this period argued there was little ethical significance to any claim putatively announcing that one type of agriculture was sustainable or that another was not. It was, I believed, much better to articulate the ethical claims that might be made on behalf of the environment, farmers, peasants or the capitalist system in more direct and conventional language. However, I did believe that there were important empirical questions to answer about whether a given practice or ensemble of technologies was or was not sustainable. By an 'empirical question' I meant that it is meaningful to question how long one would be able to continue doing what one was doing before scarcity of resources or some internal contradiction in one's practice would lead to its undoing.

There are three other dimensions to this early work that should be summarized. First, I believed then and still believe that it is impossible to answer the empirical question about sustainability without taking a systems view of agriculture, development or whatever practice is in question. By this I mean that no particular production technology, form of land tenure or other human practice is either sustainable or unsustainable in isolation. One examines a practice within a system context and then asks whether the total system is sustainable, presuming that what happens outside system borders remains stable. Taking a systems view, however, involves value judgements, and these value judgements open the door for philosophical inquiry and debate. It is, for example, possible to assess sustainability at the level of a farmer's field, and such an assessment might focus on nutrient exchange, the population of soil microorganisms or physical changes in the field due to erosion or soil compaction. Assessing sustainability in such terms presumes that the farmer is 'outside' the system. Not outside in the sense that the farmer's actions have no impact on the system. Rather, the farmer is beyond system borders in the sense that this way of understanding the sustainability of the field presumes that there will always be a farmer there to manage inputs. What if the continued presence of the farmer is itself in doubt? One can then reframe the question of sustainability by asking what system has to be in place to insure that a farmer (either a particular farmer, or any given farmer) will always be there to farm.

The broader point here is to illustrate how the definition of system borders involves a value judgement that frames the empirical assessment of sustainability. If one takes the farmer for granted, one gets one set of borders and a corresponding system that may consist largely of soil, water and microorganisms; if one asks how the farmer's continued involvement can be assured, one is dealing with a very different system, one that may involve banks, loans and government payments. Which of these perspectives, which way of defining system borders, is appropriate? My answer to this question is that it depends on what kind of practical problem one is trying to solve. Some people who write about sustainability seem to think that advanced systems modelling is a wholly value free process that will, through pure science, generate the information we need to save the planet. But my view is that the way that we conceptualize a system is deeply value laden, and reflects judgements about what is thought to be problematic, as well as likely guesses about where solutions might lie (Thompson, 1995). This point is also emphasized in Bryan Norton's recent work on sustainability (Norton, 2003, 2005).

Second, my discussion of sustainability and systems took issue with the viewpoint of Richard Bawden, from whom I have learned a great deal on sustainability on a particular question of ontology. Bawden was at the time arguing that systems are pure conceptual constructs, that there is nothing real about them. He had come to this view, I believe, out of frustration with systems theorists who had devoted what he took to be a pedantic concern with modelling physical aspects of systems and who had neglected elements of human praxis, not to mention the sense in which a system model is typically developed in response to a given felt need (Bawden, 1991; Bawden and Packham, 1993). In contrast, I argued that we would not be particularly distressed about instability or unsustainability of a system if we did not believe that the system was real (Thompson, 1995). The perishability of our conceptual constructs is not, in most instances, of great concern to us.

Pursuit of these ontological themes may prove to be an additional area where philosophers can be helpful in specifying an adequate concept of sustainability. The environmental philosopher Holmes Rolston III has argued against those who view wilderness as a 'social construction' in a similar vein (Rolston, 2001). However, a detailed pursuit of the ontological questions involved in systems science and in the definition of sustainability presupposes closure on a set of prior philosophical issues, namely those that describe the conceptual relationships between systems, system modelling and sustainability as such. It is these prior issues that are the primary focus of discussion below. A more complete discussion of ontological issues must be set aside for the time being.

Third, because of this systems approach, I have argued that it is possible for a person who is morally committed to sustainability to be overwhelmed by a more comprehensive and unsustainable system. By this I mean that someone who tries to farm or eat sustainably can be part of a society that is, in aggregate, doing itself in, and that there may be very little that any individual's commitment to sustainable farming can do about it. It is also possible for someone who neither thinks nor cares about sustainability to farm (or engage in other practices) that nevertheless contribute to the sustainability of the overall system. We can presume that many people in the past did so, for thinking and caring about sustainability is of comparatively recent origin. As such, it matters less that we promote sustainability as a personal ideal than that we pursue sustainability at a system level. This may mean that we are careful to maintain norms and beliefs that contribute to sustainability, even if they are not articulated as injunctions to pursue sustainability as such (Thompson, 1986, 1992). This aspect of my earlier views has drawn the most comment, as well as some caustic and critical responses, (see especially Campbell, 1998).

In 1994, several colleagues and I undertook a fairly extensive review of the way that people were defining and using the concept of sustainability in a variety of problem solving and policy contexts. Many of the authors we read were trying to find ways of answering the empirical questions that I had already identified as meaningful. This research did not lead me to recant my earlier views, but it did lead me to recast them. I recognized that attempts to answer the empirical questions would not be straightforward, and would involve a number of subtle value judgements. Furthermore, I came to the view that although there are dozens, perhaps hundreds, of distinct methodologies for measuring and pursuing sustainability through technical research, there are two broad paradigms for conceptualizing sustainability. These two paradigms did not contradict one another so much as they represented alternative approaches, each of which would tend to subsume the other. They differed in which questions they took to be most fundamental, and this difference had implications for how one would organize and conduct research on sustainability, how one would understand our ethical responsibility to make our practices more sustainable. The tension between these competing paradigms has also led me to think that there may be something of enduring philosophical interest here, after all. As a result, what I have been writing lately has a less cynical and more hopeful tone, and it takes sustainability more seriously.

Many of the technical approaches my colleagues and I reviewed conceptualize sustainability as a problem of *resource sufficiency.* People working within this paradigm arrive at working definitions of sustainability through the way that they approach two measurement problems. First, one must measure the rate at which a given production or consumption practice depletes or utilizes resources. Second, one must estimate the stock or store of resources available. The relative sustainability of a practice is then determined by predicting how long the practice may be continued, given the existing stock of resources. The other approach conceptualizes sustainability in terms of the *functional integrity* of a self-regenerating system. On this view, a practice that creates a threat to the system's capacity for reproducing itself over time is said to be unsustainable. This approach requires an account of the system in question that specifies its reproductive mechanisms, as well as an account of how specific practices, conceived as system activities, place those mechanisms at risk (Thompson, 1997, 1998a).

On reflection, however, I recognize that when I carve up the discourse on sustainability, I am actually left with three groups, rather than two. In addition to these two paradigms, I should add that there are still a number of people writing and talking about sustainability that seem to be making a *non-substantive* use of the word. There is a sense in which calling a practice or a pattern of conduct unsustainable is just a way of saying, 'You may get away with that this time, but eventually you'll be sorry!' This might point towards a deeper sense in which the practice or conduct will lead to its own undoing, but more frequently it is just a very general form of moral or prudential rebuke. In this sense, calling something 'unsustainable' is just a mild way of calling it bad. I was harshly critical of such talk in earlier publications, arguing that it just created confusion and muddled thinking. However, I must admit that mildness can be important, especially in the mid-west where the only thing worse than accusing someone of bad farming is to praise *yourself* as being a good farmer (or as knowing more about farming). In such contexts, the phrase 'sustainable agriculture' is just a polite way of saying 'good agriculture'.

One goal for this paper is to push my thinking on sustainability a little farther by exploring some of the implications of resource sufficiency and functional integrity within environmental ethics. Eventually, I will examine how these competing conceptions play out within the way that we understand our broad obligations to nature and to future generations, and this discussion should be relevant beyond agriculture. However, I would like to begin by returning briefly to some of the non-substantive uses of sustainability, and to consider how this way of talking about sustainability enables and promotes some very healthy activities within local *and* global debates. Here, sustainable agriculture is still my primary focus.

Non-substantive Sustainability

Dale Jamieson traces the concept of sustainable development from a 1980 report from the International Union for the Conservation of Nature and Natural Resources, through the 1987 Bruntland Commission report, to its current plethora of uses and applications. Jamieson concludes that the word is useful in structuring popular discussions and debate, but that it has little philosophical content or motivational power (Jamieson, 1998, p188). The philosophical indictment amounts to the claim that conceptualizing human activities in terms of sustainability does nothing to enhance our understanding of moral and prudential obligations associated with those activities. The second claim, that sustainability has no motivational power, amounts to the claim that characterizing one course of action as more sustainable than another will have little effect on human behaviour. I will consider these claims in turn.

First, Jamieson is right to point out that 'sustainability' is a good conversation starter, and a way to bring different interests to the table. What I have called *non-substantive* uses of the word 'sustainable' can be important in bringing people with different interests and values together. When this use generates definitions of sustainability, they tend to be highly general. Two economists offered this definition: 'We define sustainable agricultural development in this paper as an agricultural system which over the long run, enhances environmental quality and the resource base on which agriculture depends, provides for basic human food and fiber needs, is economically viable, and enhances the quality of life of farmers and society as a whole' (Davis and Langham, 1995, pp21–22). This definition acknowledges that agriculture feeds the human population, provides income for farmers and rural communities, and affects the environment, and in doing so it at least acknowledges multiple interests and multiple objectives. Yet has there ever been an agricultural technology or development project that was not intended to be sustainable, given this definition? Not every project succeeds in meeting these goals, but that just brings us back to equating 'sustainable' and 'good'.

Non-substantive uses of the term sustainable are often intended to link environmental impact with social justice. Gordon Douglass noted this in his 1984 essay on different approaches to sustainability. In most instances, authors simply assert that socially unjust practices are unsustainable (see George, 1992; Thrupp, 1993; Barkin 1998). Patricia Allen and Carolyn Sachs defend this use of the term 'sustainable', when they describe sustainable agriculture as a 'banner' under which a number of groups interested in environment and social justice have assembled (Allen and Sachs, 1992). Allen and Sachs argue that an adequate conception of sustainability must include the interests of labour, of the poor and of marginalized groups (Allen and Sachs, 1993), but this claim derives its warrant solely from the judgement that the interests of these politically weak groups should be adequately considered in any politically defensible discussion of agriculture. Allen and Sachs do not provide any argument for seeing why inclusion of these interests is related to sustainability as such.

This suggests that we can lump people who make non-substantive uses of sustainability into the 'mildness' camp and the 'banner' camp. Neither is particularly interested in what the word 'sustainability' might mean. The mild wish to use the term as a way of conveying approval and disapproval in an inoffensive manner. Banner waving organizers want to use sustainability to unify political and social causes. As Allen and Sachs (1993) are aware, one problem with the banner approach is that people with different conceptions of social justice are likely to propose different definitions of sustainability. Indeed, some authors writing on sustainable agriculture have equated sustainability with ordinary profitability, both for agricultural producers (Lynam and Herdt, 1989) and for agribusiness firms (Richgels et al, 1990).

Neither mildness nor banners get us very far in understanding what criteria should be brought forward in judging a practice to be sustainable, however. No one (well, hardly anyone) sets out to practice bad or unjust agriculture as his or her primary goal. Telling people that they should not be bad or unjust is virtually meaningless in the context of agriculture unless one also lays out some agriculture-specific criteria as to what bad or unjust means. The substantive debate concerns the standard according to which sustainability is to be judged, and this takes things beyond anything that mildness and banners can hope to accomplish. The debate over standards becomes acrimonious when either money or social approval is attached to sustainability. Everyone will want to make sure that sustainability is then measured in a manner that leaves them qualified for the rewards. People scramble to 'define' sustainability in ways that resemble the annual society page listing of who is 'in' and who is 'out', and what may have started out as politeness evolves into factional politics. Replaying the debate over social justice within a rhetoric of sustainability has not altered the familiar pattern of political alliances and ideological positions.

Non-substantive conceptions of sustainability are, thus, useful conversation starters, but the conversation does not go very far unless it eventually turns toward a serious attempt to understand what sustainability could mean in a substantive sense. The basic problem with non-substantive claims is that when we call something sustainable or unsustainable, we generally think that we are making a statement that could potentially be shown to be true or false. We thus need some conception of sustainability that does more than indicating mild approval or that reiterates the work being done by contested concepts such as social justice. One solution to this problem is to allow the values and interests of individuals working within a specific decision making context to determine the parameters of sustainability (see Walters et al, 1990). This has been the de facto approach of applied researchers for the last decade. The result is that the literature contains many technical definitions of sustainability that are inapplicable beyond the specific agronomic, economic or ecological problems for which they have been tailored. Can these problem specific approaches to sustainability be generalized?

Why Sustainability is Important

In the first phase of my work I approached the question of sustainability by asking whether it represented some sort of intrinsic good, or some comprehensive synthesis of goods. If this were the case, information about sustainability would be important because we would have an ethical obligation to pursue sustainability as such (see George, 1992). I concluded that this is not the best way to characterize the ethics of sustainability. The argument can be summarized by considering an extreme question. We can ask whether murder is sustainable in terms of resource sufficiency by measuring the rate at which murder consumes victims, and the number of victims available. We can ask whether murder is sustainable in terms of functional integrity by asking how murder threatens the human population's ability to reproduce itself. As an empirical matter, it seems likely that murder would turn out to be relatively sustainable, so long as more people are born than killed off. We are not inclined to view this fact about murder as anything in favour of the practice. We are not in the least inclined to say, 'Well, at least it's a *sustainable* practice.' From this kind of argument, I have concluded that we should view sustainability as an 'add-on' value, rather than an end in itself. Once we have deemed a practice worthwhile on other grounds, it becomes meaningful to ask whether it is sustainable, and to seek relatively more sustainable ways of securing the values or achieving the goals that make a practice worthwhile in the first place (Thompson, 1992, 1995).

Though sustainability is not intrinsically valuable, it may seem obvious that knowing which of several ways to further the sustainability of values is important for personal or social planning. Yet even this judgement needs to be unpacked. For example, consider a hypothetical problem for the resource sufficiency approach. Assume that we have determined that one food production strategy will produce a great deal of satisfaction for society at large over a few generations. Assume further that an alternative is more sustainable in that it will endure for a few more generations, but at such drastically reduced levels of satisfaction that there will be less total well-being produced even over the long run. It is not at all clear that we should choose sustainability in this case (Thompson et al, 1994). It seems we would choose the alternative that leads to more satisfaction overall.

This suggests that sustainability over time is just a dimension of the general utilitarian maxim proposed by Jeremy Bentham over 200 years ago. The maxim states that we should choose practices that maximize total well-being or utility, and Bentham describes several ways to measure utility. One of these is to increase the duration of pleasurable or satisfying experiences, but increase in duration can be swamped by increase in intensity or extent (i.e. in the number of parties experiencing satisfaction) (Bentham, 1789, p30). The underlying principle is optimization, not sustainability. Nevertheless, it must be admitted that even if sustainability simply points us towards the duration of well-being over time, it is worth including in a comparison of alternative social policies. Information about sustainability in the sense of resource sufficiency is important for planning, but not in a way that adds anything to the traditional statement of utilitarian philosophy.

So far, the argument does not provide any basis to contradict Jamieson's judgement that there is nothing novel or philosophically interesting about sustainability, but perhaps this is simply a result of the resource sufficiency approach. To examine this possibility, consider again the practice of murder. Taking first the sustainability-as-duration idea suggested by the resource sufficiency approach, we could argue that society's capacity to sustain a murder rate over time is of little value because the costs or harms associated with almost any given murder outweigh any benefits. Lengthening the duration of a murder rate for society might be a good thing in comparison to an alternative where the murder rate increases, but not because of sustainability. The moral judgement is simply a matter of the total welfare produced by each alternative. Duration, again, is only a dimension of the increase or decrease in total utility, total benefit and harm.

Switching to a functional integrity approach, we ask how murder threatens a society's ability to reproduce itself. We might first assess the question in terms of biological births and deaths, but the sustainability of murder is, on the face of it, a much more complicated question than whether there are enough victims to keep up the killing. We are led immediately to consider whether a given murder rate, or perhaps murders of a particular kind or within a particular sector of society might threaten democratic or family institutions. Answering these questions might, in turn, lead us conclude that even if the birth rate is adequate to supply a continuous stream of victims, murder *does* threaten a society's ability to regenerate its fundamental institutions. *This* conclusion adds something to the urgency with which murder is understood as a social problem. The harm done by murder is itself sufficient reason to expend resources on police and courts, but the stakes are even higher when we become convinced that it threatens fundamental institutions.

I believe that a similar comparison can be made for ecological, environmental and agricultural applications of these two approaches, though the issues are more complex. If we take a resource sufficiency approach to food production, the problem is still one of balancing costs and benefits. The accounting becomes very complicated and contentious, in part because there is little consensus about the environmental costs of food production. There is far less agreement than with respect to the costs and benefits of murder. Yet if we did reach consensus on the costs and benefits of food production, the value of sustainability would be entirely subsumed in this larger optimization problem. We would compare the relative costs and benefits of different ways for producing food. The comparison would be made difficult by the disparity between different kinds of cost or benefit (e.g. gustatory *vs* nutritional value; producer *vs* consumer benefit; human *vs* ecosystem health), but sustainability-as-duration would certainly be one of least difficult aspects of the comparison to accomplish.

Consider then how food production affects our society's ability to reproduce itself. This, too, is a problem of almost overwhelming complexity, for society must be understood as a system comprising many subsystems that are threatened in different ways by different approaches to producing food. One aspect of social reproduction is the regeneration of our bodies, a reproductive process that requires food consumption. The human population's need for food sets one system parameter, but in meeting this parameter it is possible to deplete soil, water and genetic resources used in food production. Since each of these is a regenerative subsystem, threats to these subsystems represent threats to total system sustainability. Similarly, farms and rural communities represent subsystems. If farming is unprofitable, or if the local institutions that support farming are not regenerated, the sustainability of the larger system is threatened. Our desire to maintain the functional integrity of all these subsystems might make us conservative in the sense advocated by Edmund Burke. That is, we might be very cautious about 'improving' a subsystem that seemed to be functioning well enough for fear that what we would do might upset the complex interconnection of the whole.

Far from understanding sustainability as one dimension of optimization, we would understand it as a relative equilibrium among social and natural subsystems, an equilibrium that we challenge at our peril. We might say that we value these natural and social subsystems because they provide the context or the constitutional basis for personal and group identity, and for the formation of preferences that would give rise to a given conception of well being. Nevertheless, I believe this stops short of making sustainability into an intrinsic value, for we would feel considerably less compunction about interfering in a system that did not seem to be functioning well. It might be worth some risk, in other words, to change a social system that produces wretchedness and social injustice in large measure. I also hasten to add that this conception of sustainability would not entail conservatism in every case. If our knowledge about threats to system integrity indicated that our food production system was headed for collapse, sustainability-as-functional integrity would provide a basis for even extreme restorative measures.

We may summarize and tie this discussion to a broader literature in ethics and political philosophy. Resource sufficiency points towards an interpretation of sustainability as a measure of the duration associated with practices that produce (or detract from) well-being. It leaves questions about whose well-being and the relative measure of different forms of satisfaction open. It is consistent with the general form of the utilitarian maxim, and indeed seems to specify nothing more than the temporal dimension of it. It is therefore an important component of the information we need to carry out moral and political duties conceptualized in utilitarian terms, but it is not particularly interesting from a philosophical perspective.

Functional integrity, however, describes the mechanisms that allow whole systems, (such as human societies or human dominated ecosystems) to regenerate themselves over time. System-level stability manifests itself in social institutions, renewal of soil, water and genetic resources (including wildlife), and cultural identity. The basis of our obligation to maintain this stability is sometimes obscure but can be expressed as prudential advice to be cautious about very uncertain risks. It may also be expressed in more communitarian terms as a duty to maintain the integrity of institutions and natural processes that are the basis for our collective sense of identity and purpose.

Resource Sufficiency *vs* Functional Integrity

The concepts that have been sketched out above are problematic in more ways than can be discussed in a single essay. The problematic character of these general approaches to sustainability is what accounts for their philosophical significance. If sustainability were just the temporal dimension of a maximization rule, it would not merit much philosophical analysis. But sustainability is a contested concept, with functional integrity advocates claiming that it describes part/whole relationships in a way that is central to socio-natural organization of human activity. It is therefore worth taking some pains to clarify and understand what is being contested, and how functional integrity is different from resource sufficiency. The present format avails scope for discussing only one dimension of this comparison and contrast, so the goal here is not to exhaust the philosophical analysis of sustainability but merely to tease readers into a continuing philosophical discussion. What is more, resource sufficiency and functional integrity are not so easily distinguished once empirical analysis begins. There is less difference in the way that these two approaches portray the facts than might appear. However, the empirical interconnections only serve to underscore the way that advocates of each approach are interpreting facts normatively different ways.

Any attempt to carry out the empirical measurement and system modelling implied by resource sufficiency and functional integrity will tend to bring these two approaches to sustainability together. Consider what an analyst attempting to evaluate the sustainability of a given strategy for food production would do. Measuring the resources needed to produce food would lead one immediately to renewable soil, water and genetic resources. Accounting for the availability of these resources over time requires knowledge of the rates at which they are replenished. The resource sufficiency analyst is thus led to many of the same questions as the functional integrity analyst. Production strategies that maintain the functional integrity of regenerative subsystems for renewable resources are likely to come out as 'more sustainable', on either the resource availability or the functional integrity approach.

Given this similarity, why is there a debate at all? Jamieson reviews the debate between advocates of *strong sustainability*, who insist that natural capital must not decline over time, and those who advocate *weak sustainability*, that is, that human well-being does not decline over time. Both groups operationalize their respective conceptions of sustainability with accounting arguments of a resource sufficiency kind. The primary difference is that weak sustainability presumes that one means for maintaining human well-being is as good as any other. Crucially, they believe that it will be possible to maintain well-being by substituting human for natural capital (see Pearce, 1993). Advocates of strong sustainability believe that future generations have a right to the same amount of natural capital as present generations, and that protecting this right places a prior constraint on preference maximization by present generations (Howarth, 1995; Bromley, 1998). Norton also stresses the difference between strong and weak sustainability as approaches in ecosystem management (2003, 2005). Here again, I will emphasize agriculture.

Strong and weak sustainability represent significantly different perspectives for evaluating agriculture. Specifically, advocates of weak sustainability may see agricultural science as a way to compensate for declining soil fertility, water quality or genetic variability. To say that human capital is substituted for natural capital is economists' talk for saying that science will continue to increase yields, even as the renewable resource base declines. Norton and other advocates of strong sustainability reject this strategy, claiming that it violates the rights of future generations. This approach is consistent with resource sufficiency approaches to the measurement of sustainability. It is consistent with the welfarism of utilitarianism (i.e. the view that it is the well-being of individuals that is ethically important) and differs from classical utilitarianism primarily in 'taking rights seriously', in this case, the rights of unborn future generations. Thus the basic philosophical machinery in this approach to strong sustainability is consistent with recent work in ethics and political theory that is largely unconcerned with and uninformed by ecology or principles of functional integrity. Key work in reconciling rights with the consequentialism (i.e. understanding ethics as being intrinsically engaged in the comparing the expected consequences of alternative courses of action) was accomplished by Ronald Dworkin (1977) and Amartya Sen (1987). This approach does not demand a systems analysis or orientation, and presupposes only that one has some reasonably reliable means for predicting the consequences of one's action, generally as a sequence of causal relationships.

Yet one wonders whether there is not a functional integrity argument lurking in the background of strong sustainability. One way that systems can creep in to the strong sustainability view is when predicting the consequences of human action is done using models that are, effectively, systems-based. However, this makes it seem as if the predicting is purely a scientific activity. One of Norton's key points (2003, 2005) is that it is important to avoid a 'value-free' notion of science precisely because doing so conceals key value judgements that may have been made in conceptualizing system borders. The chance of such concealment is significant when the systems orientation is buried in the model being used to predict outcomes. Thus one philosophical advantage of functional integrity is that the language in which sustainability is articulated invests the system of interest with significance in an obvious way. Clearly, the only way that natural capital can be preserved consistent with rights of present generations (let alone future ones) is to utilize renewable natural resources within their capacity for regeneration and renewal. In *saying* that sustainability is about the integrity of the renewable resource subsystem, as opposed to welfare or rights, one surfaces the values implicit in viewing natural resources as a system capable of regeneration.

Another argument for resisting the dependence on science that is implicit in a resource sufficiency approach also points us toward functional integrity in stressing that key vulnerabilities reside in social (rather than soil and water) subsystems. First, if science is generating the technology crucial to meeting food needs, we must be sure that the subsystem that supports agricultural science is itself secure, and that there are good reasons to think that continuous increases in yield are in store. Yet funding for agricultural science has declined steadily over the last decade, and as the number of farmers who lobby for research declines, it is not at all clear that social apparatus needed to support the research system is stable (Buttel, 1993). Second, increases in yield have been accompanied by patterns of industrialization in agriculture that deplete rural populations, and that shift farmers' economic livelihood away from dependence on soil, water and genetic resources, and toward dependence on finance. This shift strikes to the heart of the sustainable agriculture movement, for people fear that the social and biological systems that support agriculture have been weakened, and that farming has shifted toward greater dependence on an inherently risky system for regenerating financial capital. Each of these subsystems is seen as becoming more brittle as we drift towards industrial agriculture.

I am not asserting that risks to the science subsystem or the rural community subsystem have been proven. My point is simply to sketch the implicit links between strong sustainability and a functional integrity point of view. However, this sketch does suggest that a more explicit statement of the functional basis for imputing rights to future generations would result in a more plausible and more potent philosophical statement of the case for strong sustainability. Although advocates of strong sustainability use the accounting language of resource sufficiency, it seems likely that their conservatism derives from a deeper consideration of the way that food production depends on the continued performance of many interlinked subsystems. They believe that unbridled industrial agriculture poses significant risks to the stability of social, scientific, financial and renewable resource subsystem. They therefore challenge the weak sustainability estimate of resource availability. Ultimately a defense of this viewpoint depends more heavily on a plausible account of risks to system integrity than on the imputation of rights to future generations.

Conclusion

Jamieson's negative assessment of the philosophical richness in various conceptions of sustainability is unwarranted. Even if one is inclined to favour a simple norm of optimization, one must admit that resource sufficiency and functional integrity present philosophically complex alternatives for conceptualizing the nature of human responsibility to act sustainably. However, I am only slightly less pessimistic than Jamieson about the motivational effectiveness of sustainability. On the one hand, I hope that I have shown why sustainability is important, and why getting a clearer understanding of sustainability is crucial to policy planning and project management. On the other hand, the sheer complexity of sustainability (the fact of which is part of my argument for treating it as a philosophical problem) weighs against its use as an idea that can mobilize mass political movements. It is questionable whether it can be useful in motivating individual behaviour.

This leaves us with the paradox of sustainability. On the one hand, the human polity ought to act sustainably. On the other hand, the human polity cannot mobilize around the goal of sustainability. Looked at in one way, there is no contradiction here. It is just a way of saying that it is better to be lucky than smart. If we have simple norms that provide little insight into the regenerative systems of ecology and society, but that guide our behaviour in ways that allow those systems to function, we should retain those simple norms. We ought *not* replace them with complicated conceptual or mathematical models that are 'smart' in providing predictive knowledge of system failure, but that are too complex for people to follow on a day-to-day basis (Thompson, 1995; Grant and Thompson, 1997).

While not strictly paradoxical, the upshot is at least ironic. Though we ought to improve our understanding of sustainability in a deep sense, and despite the fact that non-substantive discussions of sustainability make this more difficult, non-substantive talk about sustainability may be more sustainable (in the sense of promoting a genuinely sustainable society) than reforming the public discourse with an ecologically and philosophically richer idea. Mora Campbell has taken me to task for advocating this position. She claims that since my conceptualization of sustainability establishes a system perspective that is unavailable to people making decisions on a day-to-day basis, I have established a normative framework that is inherently elitist and exclusionary. According to Campbell, a conceptual apparatus that demands an ideal observer's perspective for establishing its normative claims is normatively unacceptable because any acceptable normative perspective must, in principle, be accessible to all (Campbell, 1998).

Campbell does *not* mean that every person must be able to 'occupy' or have deep affective sympathy with a perspective for it to have moral validity. That would be contrary to the general principles of the feminist critique her paper undertakes. Feminist thought in environmental ethics has promoted an interpretation of rightness (or the normatively correct) that is capable of accommodating deep incompatibilities in perspective (Warren, 2000; Plumwood, 2002) This is not the place to launch into a detailed discussion of feminist thought, but Campbell's critique shows, contra Jamieson, that even if my approach to sustainability is motivationally weak, it is weak in a philosophically interesting way.

In reply I offer two concluding disclaimers and qualifications that hopefully deflate the elitist and exclusionary pretensions Campbell associates with my position. First, although I have argued that the systems-modelling approach to sustainability yields a conceptualization more adequate to the task of reforming conduct and policy, I have *not* argued that adopting this approach is either a necessary or sufficient condition for adequate moral decision making. Normative inquiry is complex and I agree with the main thrust of the feminist critique: it is important to both figuratively imagine and to actually conduct inquiries into the norms and goals that guide our lives in an open and welcoming manner. We should not dismiss different views as 'irrational' nor should we try to police our normative discourse in light of philosophical conceits. We should instead try to hear and accommodate each other's voices (Thompson, 1998b).

Second, I have *not* argued that we should allow the numbers that hard systems models generate to override other considerations when reviewing how to adjust our conduct or policy. Indeed, I do not think that specific predictions and measurements of either resource sufficiency or functional integrity should be given much weight at all. In fact I think that it is very likely that current models omit crucial factors and that to rely on them too heavily in policy making would be to fall victim to the fallacy of 'state simplifications' (Scott, 1998). The argument that I *have* made is that the systems-modelling approach yields an informative and normatively more adequate *conceptualization* of sustainability, one that gives us a better sense of what we are shooting for, one that helps us better understand what our adjustments, approximations and ameliorative strategies should be striving toward. Models can also reveal patterns of association and interaction that tend to be maintained among various system elements, including human activity. Such revelations are normatively useful, even when the predictions are imprecise.

In my view, sustainability is neither equivalent to norms that we have long associated with democracy and social justice, nor should it be presumed that achieving these norms will necessarily result in a sustainable society. Yet people seeking to make their societies more sustainable at the same time that they seek to make them more democratic or more just would be well advised to develop an understanding of sustainability that has been informed by the lessons of ecology and systems modelling. They should also regard the definition and conceptualization of sustainability as a philosophically open ended and always evolving task. We will never have a complete understanding of sustainability; we must always be willing and eager to think it through again.

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5

Learning and Mislearning

Robert Chambers

How we learn and mislearn about canal irrigation systems has not itself, to my knowledge, been a subject of research. Yet how our beliefs are formed and sustained deserves a hard look. This chapter examines examples of research and innovation. Two sets of accessible data are considered. The first is three studies made of the left bank of the Mahi-Kadana Project in Gujarat. The second is action research undertaken on the Mahanadi River Project and Hasdeo Bango Project in Madhya Pradesh. In analysing these, and in subsequent discussion of pilot projects and 'islands of salvation', my approach is critical. But it is easier to criticize than to do. It is not hard to find holes in any pioneering research or action, especially when the arena is as complex and varying as canal irrigation. The courage of those who run the risks of research and action is to be applauded. The spirit of this chapter is positive, to learn lessons and to contribute to the collective struggle, to get closer to the truth.

Mahi-Kadana: Seeing Parts and Missing Links

Unusually, the Mahi-Kadana Project in Gujarat has been the subject of three separate and substantial multidisciplinary studies, each with a different purpose, orientation and disciplinary composition. Each study reveals different aspects of the project, and leads towards different practical conclusions.

The Mahi-Kadana Project itself developed in two stages. The first was the construction of a weir across the river Mahi at Wanakbori in 1958. This diverted run-of-the-river flows primarily for the kharif (monsoon) season, to supplement rainfall. The second stage was the construction of the Kadana reservoir upstream, in 1978. Storing and releasing water from this reservoir was designed to enable rabi (winter) and summer crops to be grown. The three studies were concerned with the larger Mahi Right Bank (MRB) and not the smaller Mahi Left Bank, and all discussion and figures which follow refer only to the MRB. In 1980–1981, the Cultivable Command Area of the MRB was reported to be 213,000ha, with an

Reprinted from Chambers R. Learning and mislearning. In *Managing Canal Irrigation.* Cambridge University Press, Cambridge 1988

irrigation intensity of 55 per cent as against 131 per cent proposed by the Government of Gujarat (WTC, 1983, p356). A Command Area Development Authority (CADA) programme was launched in 1974, and was concerned with on-farm development (OFD) and later with farmers' organization for the distribution of water, all of this below the outlet. The main crops were paddy in kharif and wheat in rabi, with also a large area under eight-month tobacco. The period during which the three studies were conducted was also that of the first five years of flows from the Kadana reservoir, when rapid changes were taking place in the MRB as the extra water was available, including extensive OFD work under the CADA programme.

The three studies had different purposes and were conducted by researchers from different disciplines, as shown in Table 5.1.

The first and earliest study, *Command Area Development in Mahi-Kadana* (Asopa and Tripathi, 1978) was carried out by two staff members of the Indian Institute of Management, Ahmedabad – an agricultural economist with a background in

Table 5.1 *Three studies of Mahi-Kadana Right Bank command area*

Institution	*Stated purpose*	*Title of publication*	*Disciplines involved in study*
Indian Institute of Management, Ahmedabad	An in-depth understanding of the integrated area development approach in the command area	*Command Area Development in Mahi-Kadana* (Asopa and Tripathi, 1978)	Agricultural economics Agriculture Sociology
Water Technology Centre, Delhi	Broad objectives included 'the resource analysis of the project area and development of guidelines for efficient land use and water management in the MRBC command area'	*Resource Analysis and Plan for Efficient Water Management: A Case Study of Mahi Right Bank Canal Command Area, Gujarat*, (WTC, 1983)	Agricultural engineering Hydrology Agronomy Biometrics Statistics Soil physics Water conservation engineering Soil science Climatology Agricultural economics
Water Management Synthesis Project, Colorado State University	Training, and also 'to describe the actual operation on an irrigation system in relation to design specifications, and to identify the positive and negative aspects of the system through an interdisciplinary analysis'	*Diagnostic Analysis of Farm Irrigation Systems in the Mahi-Kadana Irrigation Project, Gujarat, India* (WMSP, 1983)	Agronomy Economics Irrigation engineering Agricultural engineering Extension/sociology

agriculture, and a sociologist. They noted that the World Bank-assisted programme in the command of Mahi-Kadana was one of the first few attempts to implement the command area development approach.

Their study was an attempt at gaining an in-depth understanding of the integrated area development approach in the area. The specific objectives were to study the planning of the integrated area development programme, to understand the implementation processes, and to assess the farmer's perception of the programme, his needs and receptivity (Asopa and Tripathi, 1978, p12).[1] There was no requirement to produce a plan. The method included study of documents, interviews with knowledgeable people and a survey of 50 farmers to know their reactions to the philosophy of the programme, its implementation and its usefulness in increasing agricultural production.

Asopa and Tripathi wrote a 112-page report which was ahead of its time in the stress it laid on farmers' participation in decision making for water scheduling, rotation periods and other aspects of water management They argued that 'the major lacuna continues to be either limited or erratic availability of water'. As long as that continued, 'no amount of administrative innovativeness, support or vigilance would promote irrigated agriculture'. They proposed water cooperatives which would distribute water and ultimately become bulk purchasers of water (Asopa and Tripathi, 1978, pp103–109). This was, then, a study which set out to examine Command Area Development and farmers' views, and found its attention directed by the farmers towards the main system and water scheduling and delivery.

The second study, *Resource Analysis and Plan for Efficient Water Management: A Case Study on Mahi Right Bank Canal Command Area, Gujarat* (WTC, 1983) was carried out by some 16 scientists of the Water Technology Centre (WTC), Delhi, including the disciplines of agricultural engineering, hydrology, agronomy, biometrics, statistics, soil physics, water conservation engineering, soil science, climatology and agricultural economics. The report (WTC, 1978, p7) states that:

> The broad objectives of this programme include the resource analysis of the project area and development of guidelines for efficient land use and water management in the MRBC command area. The studies included the collection, compilation, analysis and interpretation of all available data and information on the irrigation project.

Secondary data were collected from official sources, and primary data were collected on soils.

The 360-page report reflects the disciplines of those who took part. The main chapters, after an introduction, are:

- Climate.
- Soils.
- Irrigation.
- Drainage.

- Groundwater Development and Management.
- Impact on Environment.
- Canal Scheduling and Water Course Alignment.
- On-farm Development.
- Ancillary Resources and Infrastructure.
- Irrigation Cooperatives.
- Crop Planning and Irrigation Management.
- Water Resources Utilization and Management.

Disciplinary specialization, quantitative methods and the presentation of statistics are marked in most chapters. The focus on water is strong, with descriptions of the physical irrigation system, the official norms for system management and operation, annual water balance calculations and analysis of groundwater conditions. Groundwater was found to be rising at about a metre a year during 1976–1980, threatening waterlogging and salinity. A final chapter by P. B. S. Sarma, N. H. Rao and A. M. Michael on 'Water Resources Utilisation and Management' examines the water resources assessed as available, and the original plans for the system, which did not include extensive use of groundwater. Sarma and his colleagues propose conjunctive use of groundwater. With conjunctive use, they calculate that the intensity of irrigation, based on a Culturable Command Area of 213,000ha, could be raised from the 55 per cent reported achieved in 1980–1981, and beyond the 131 per cent proposed by the Government of Gujarat, to 180 per cent (WTC, 1978, p356). This would simultaneously help to arrest the rise in the groundwater table and increase the intensity of irrigation.

The third study, *Diagnostic Analysis of Farm Irrigation Systems in the Mahi-Kadana Irrigation Project, Gujarat, India* (WMSP, 1983), was an outcome or by-product of a five-week professional development diagnostic analysis workshop held in early 1981 as part of the United States Agency for International Development (USAID) supported Water Management Synthesis Project (WMSP), the main objective of which was training. Studies were carried out by trainers and participants in the disciplines of agronomy, economics, irrigation engineering, agricultural engineering, and extension and sociology. The objectives of the workshop were:

1. to provide the participants with the skills required to monitor and evaluate irrigation projects, thus enhancing the capacity and the capability of the government to improve irrigation facilities and management throughout Gujarat;
2. to describe the actual operation of an irrigation system in relation to its design specifications, and to identify the positive and negative aspects of the system through an interdisciplinary analysis. (WSMP, 1983, p3)

The authors of the report note that the training objective deliberately restricted the amount of data collected, so that the report simply indicated areas of constraints in the system.

The method included interviews with staff and farmers and detailed interdisciplinary field investigations at the on-farm level including measurements of water flows. The main system was included but the principal focus was below the outlet. The report is unusual for the attention given to the problems and views of both officials at different levels, and farmers. This emphasis is reflected in the sequence of sections in the report, starting with extension, and then with economics, engineering and agronomy in that order.

Three findings deserve remark. First, most farmers were found willing to pay seven to nine times more for private tubewell water than for public canal water. This was because tubewell water was predictable and controllable (WSMP, 1983, p52). Second, flows through outlets, far from being constant, were highly variable during both day and night as they were also in the canals (WSMP, 1983, pp87, 89, 99, 102, 136). And third, conveyance losses below the outlet were estimated to be 50 per cent (WSMP, 1983, p110).

Analysing and comparing these three studies, three points stand out.

Partial views and complementarities: Each study reflects the interests and methods of the investigators, covers a different range of topics, and leaves much out. If the proper names were excluded, one might not know that the three texts referred to the same system. However, when taken together, the three studies are complementary, and qualify and correct each other. For example, the WTC study includes a water balance analysis which is not based on empirical measurements of transmission losses, and assumes losses of 30 per cent below the outlets. The WMSP study found empirically that losses averaged about 50 per cent below three outlets. If 50 per cent is representative, then the WTC estimates of water availability and potential intensities for the whole system should be much lower.

Mutual ignorance: Asopa and Tripathy reported in 1978, yet I have been unable to find any reference to their work in the WMSP and WTC reports published in 1983. T. K. Jayaraman (1982) wrote prolificly on Mahi-Kadana (on cropping patterns, farmers' organization, on-farm development, rotational water supplies, the attitudes of the irrigation bureaucracy etc.), but the only mention of his work I can find in the WTC report is a paper on malaria (Jayaraman, 1982). Most striking of all, the WMSP and WTC teams appear to have worked in ignorance of one another. The complementarities which might have been exploited to mutual benefit were not realized.

Missing links: The three studies sometimes touch upon, but do not investigate in detail, key linkages and gaps in knowledge. In a common sense view of Mahi-Kadana as a system, missing links likely to be significant might include:

- Labour shortages at peak periods.
- Actual flows and regulation of the main system.
- Irrigation flows at night.
- Farmers' activities above the outlet.
- Farmers' costs (in payments, hassle, time, uncertainty) in obtaining a water indent.

- Farmers' knowledge of main system management and water supplies, and manager–farmer communications.
- Incentives and disincentives for irrigation staff.
- The operation of the groundwater market.

None of these are examined in any depth in any of the three studies. Without more insight into most or all of these, prescription for improving performance might easily be wide of the mark.

MRP and HBP: Failure through Success

In kharif 1979 the consultants Water and Power Consultancy Services (WAPCOS) conducted ambitious and inherently difficult research on two major canal irrigation projects – the Mahanadi River Project (MRP) (CCA about 180,000ha) and the Hasdeo Bango Project (HBP) (CCA about 41,000ha), both of which grew paddy in kharif with protective irrigation. The objective of the research was to ascertain the advantages, if any, of reducing chak size. Normal chak sizes ranged from 8ha to over 200ha. The experimental treatment reported was to subdivide trial chaks by constructing subminors down to 8ha subchaks, and then rotate the water supply between the subchaks. Of 14 outlets selected, 3 became trials and 11 were controls. Measurements reported included water supplied, rainfall, farmyard manure and chemical fertilizers used, percentages of chaks and subchaks planted to high-yielding varieties (HYVs) and transplanted, and yields at different locations in chaks and subchaks, using crop-cutting. It was reported for WAPCOS (Chadha, 1980, p388) that these field studies:

> demonstrated dramatically the effect of delivering water through Government constructed channels up to smaller chaks (of 8ha in this case)... Our recommendations, supported by field studies carried out as part of consultancy services are for 8ha subchaks which means that the size of subchak was limited to 4 or 5 farmers, and length of water course serving it is limited to 300m or so, which are much more manageable. It is a matter of happiness that Govt. of India also accepted these findings and have issued new guidelines on the subject.

The adoption of these recommendations as government policy is confirmed by the record of a conference held in April 1980 which reported the then Secretary of Irrigation as saying:

> The Government of India and the Planning Commission have requested the State Governments to extend field channels to 5–8 hectare blocks, on the canal system. (Patel, 1981, p9)

Let us examine the methods and evidence of the research on which, it would seem, this policy decision was based. In doing this, the most favourable assumptions will be made. The measurement of water flows, of input supplies and applications, of areas under HYVs and transplanted, and of crop yields through crop-cutting are all subject to methodological problems, and often wide margins of error. Although there is no reason to suppose this research was exempt from these difficulties, and although the WAPCOS report makes no mention of them, the critique which follows assumes complete accuracy of measurement and reporting. Full acknowledgement must also be given to the difficulties recognized by the researchers. The 1979 monsoon was poor and less water than normal was available, especially on the HBP. Low rainfall affected crop yield directly through water scarcity, and indirectly through increased pests and diseases. Cultivators were free to use whatever inputs they wished, weakening some aspects of the comparison of trial chaks with control chaks. The Government of Madhya Pradesh could only construct channels down to subchaks for three outlets – two on MRP and one on HBP. Finally, of these three, the one on HBP received very little water, and one of the two on MRP had a severe attack of gall midge.

In its conclusion, the WAPCOS (1980) report stated that it had briefly reviewed 'Exhaustive, most valuable and reliable data as collected', and then summarized its findings. Some findings were also presented in a subsequent paper (Chadha, 1980). Those especially relevant to the policy decision for smaller subchaks were:

1. *acceptance*: subdividing of a large outlet chak into smaller subchaks as irrigation units found general acceptance from the cultivators (WAPCOS, 1980, p30);
2. *time taken to irrigate*: 'the time taken for irrigating the entire command of an outlet was 5 to 14 days as against 20 to 45 days for normal outlets without subchaks' (Chadha, 1980, p388. Chadha, 1981, p70 specifies this as the time for providing first irrigation);
3. *uniformity of yield*: the variation in yield within an outlet command was less when it was divided into smaller units (WAPCOS, 1980, p30);
4. *yield*: with smaller subchaks yields were 70 to 137 per cent higher compared to the normal outlets (Chadha, 1980, p388).

The syntax used in both sources implied that the benefits were the result of the experimental treatment of subdivision and rotation.

The procedures and analysis throw doubt on the validity of these conclusions. To understand why, we must look at the detail of the procedures and analysis employed. Three methodological defects can be noted.

First, two of the three trials were eliminated from most of the comparisons because they performed badly, but none of the 11 controls was eliminated. In mitigation, none of the controls was reported to have suffered as severely as these two trials from their respective problems – a gall-midge attack, and receipt of very little water respectively. All the same, no analysis was made of the reasons for the gall-midge attack or the little water received or whether these were related to the trial treatment. Nor was the failure to eliminate any of the controls discussed or justified. Most of the conclusions were based on the one remaining trial chak with subchaks, the Koliary outlet, comparing its performance with that of the 11 controls.

Second, the Koliary outlet had a privileged location compared with the controls as a whole. It was accessible to administrative headquarters at Raipur. It was on the MRP which had more water than the HRP. It was selected because it would be possible to assure a water supply. And it was well placed on the canal system, being at the head of a distributary at the head of the canal. The relative positions are shown in Table 5.2.

Third, the Koliary chak received special treatment. Before the kharif season, the farmers on the Koliary outlet were asked if they would be prepared to plant

Table 5.2 *Details of trial and control chaks, MRP and HBP*

System Chak	*Position of distributary on canal*	*Position of chak on distributary minor*	*Outlet Command (ha)*	*Number of days taken for completing first irrigation*	*Status C = control*	*Accepted or rejected*
MRP						
1 (Saja)	Head	Head	71.2	14	Trial	Rejected (gall midge)
2 (Koliary)	Head	Head	23.6	5	Trial	Accepted
3	Head	–	42.3	8	C	Accepted
4	Middle	Head	16.9	27	C	Accepted
5	Middle	–	50.0	17	C	Accepted
6	Middle	–	43.5	6[a]	C	Accepted
7	Tail	–	45.0	10[a]	C	Accepted
8	Tail	–	44.1	8[a]	C	Accepted
9 (Kurud tank)	–	–	32.35	22	C	Accepted
HBP						
10	Head	Head	49.1	16	C	Accepted
11	Head	Head	18.9	6[a]	C	Accepted
12 (Mudapar)	Middle	Head	79.6	25[b]	Trial	Rejected (little water)
13	Middle	Head	46.9	46[b]	C	Accepted
14	Tail	Head	43.5	7	C	Accepted

Notes:

[a] 'Due to heavy rainfall on 8.8.79'.

[b] 'The supply was intermittent. The days of interruptions in canal supplies have been omitted'.

Source: WAPCOS, 1980, pp8 and 15

HYVs, use fertilizer and transplant. They said they would do so only if their water supply and other inputs were assured. This was agreed. Special efforts were made with the bank, and with seed and fertilizer supply, to ensure that farmers could obtain the necessary inputs. The subminor had a continuous flow all through the season with a flow of 4 to 5 cusecs to a lower area which was itself never short of water. Farmers could always see water flowing past their outlets, even when they were not receiving it.

To the best of my knowledge and belief, none of the controls with which the comparisons were made received the same special treatment of negotiation, guaranteed water supply, or arrangements for credit and input supply.

In the light of these procedures and other evidence let us now look at each of the four findings.

Acceptance by cultivators. No indication is given of how the 'general acceptance' was assessed, nor whether this included the two trial subchaks which were rejected, but it is scarcely surprising if the Koliary outlet cultivators accepted assurances of a guaranteed water supply, credit and inputs. Indeed, the benefits from these could override other inconveniences if they were a necessary price to pay. Had there been negative attitudes to subdivision and rotation, they could have been obscured by welcome for unprecedented access to credit and other services. In sum, this finding cannot be said to have been established.

Time taken for irrigating the entire outlet command was 5 to 14 days as against 20 to 45 days for normal outlets without subchaks. The figures cited in the finding are not those of the report. The comparison of 5 to 14 days with 20 to 45 days looks decisive and impressive. However: if the averages for all the chaks are taken, the average for trials was 15 days and for controls 17 days, hardly a decisive difference; the 5 to 14 figure for trials is reached by accepting the two better performing trial chaks, which were reported to take 5 and 14 days respectively, and rejecting the trial chak on HBP which was reported to have taken 25 days. No control chaks were rejected; the 20–45 days figure for controls is more difficult to understand. The report gives a range of 6 to 46. Four of the controls, taking 6, 6, 8 and 10 days respectively were said to have had heavy rainfall which shortened their irrigation. This rainfall was not reported to have affected any of the trials. But even if these four control chaks are eliminated on the grounds of heavy rainfall which they alone received, the controls remaining took 7, 8, 16, 17, 22, 27 and 46 days respectively, giving a range of 7 to 46, not 20 to 45.

Thus, instead of 5 to 14 for trials and 20 to 45 for controls, the correct comparison would appear to be 5 to 25 for trials and 6 or 7 to 46 for controls. The figures officially quoted as 'findings' are difficult to explain.

A more plausible interpretation is that time taken to irrigate the entire outlet command was a function of position on the main system and of the water supply. This is suggested, for example, by comparing the two trials with head locations on the MRP with the MRP control which had a comparable head location. The performance was closely similar, as follows:

Saja (trial)	71.2ha in 14 days = 5.1ha/day
Koliary (trial)	23.6ha in 5 days = 4.7ha/day
Dy 10/MMC (control)	42.3ha in 8 days = 5.3ha/day[1]

Variation in yield within an outlet command was less when it was divided into smaller units. For variance of yield within an outlet command, the Koliary outlet was compared with the 11 controls.[1] The variance in yield of the Koliary outlet was arrived at by comparing the average yields of the three subchaks (lowest subchak 87, highest subchak 120, with 100 average). For the 11 control outlets, however, variance was obtained by comparing average yields for the head areas of all 11 outlets with average yields for all their tail areas (tail areas 68, head areas 127, with 100 average). Arrived at differently, the Koliary and control figures are not comparable, and no conclusions can be drawn.

With smaller subchaks yields were 70 to 137 per cent higher compared to the normal outlets. The 70 to 137 per cent higher yields appear to be based on a comparison of yields on the Koliary outlet with respectively the 11 controls (Koliary was 70 per cent higher) and the 57 outlets on both systems which were subject to a major crop-cutting survey (Koliary was 137 per cent higher). The question is whether these higher yields could be attributed to smaller subchaks and rotations.

Some relevant data for the controls are in Table 5.3.

The WAPCOS Report (1980, p26) while conceding that 'The increased yield on Koliary might be partly due to the larger input of fertilizers' goes on to assert 'but mainly it was due to reducing the command into smaller irrigation units'. But such a conclusion could only follow from a careful analysis controlling for different variables. The surprise is that the Koliary outlet, with its special water supply, HYVs and inputs, achieved only 2.065 tons/ha and not more. Some other factors may have held down yields. A perverse possibility cannot be excluded: that, far from enhancing yields, subdivision and rotation actually depressed them.

This review of the evidence, concludes that the four findings about the good effects of subdivision of chaks and rotation of water between subchaks were unfounded. The larger survey of 57 chaks showed sharp gradients of declining

Table 5.3 *Trial and control inputs and yields*

Input	*11 control outlets without subchaks*		*Koliary outlet with subchaks*
	MRP	HBP	
Irrigation (mm)	395	171	311.5
Percentage HYV	62	Nil	100
Farmyard manure kg/ac (*sic*)	1854	890	1590
Urea, phosphate, potash and others kg/ac (*sic*)	43	23	154
Yield of rice kg/ha (*sic*)	1225	1185	2065

yields as one passed from head through middle to tail along canals, distributaries, and minors, and within outlets (WAPCOs, 1980; Lenton, 1983) and indicated location on the main system as a powerful explanation of differences in yield and other indicators of performance. When similar but rigorous research on subdivision and rotation was conducted by Wickham and others in the Philippines in the early 1970s (Wickham et al, 1974; Lazaro and Wickham, 1976; Wickham and Valera, 1978) the yield differences with subdivision and rotation were not significant compared with the control. The researchers went straight on to infer that location on the main system and water deliveries were more important. Through painstaking, good research, they identified main system management, and not subdivision and rotation, as the priority. It was tragic that India was not equally well served, and that, in contrast, the Government of India and the World Bank were pointed, at great expense, in a direction which the research did not justify, and away from main system management as the priority.

The research, it seems, was so focused on subdivision and rotation between subchaks that other explanations or findings were largely excluded. Interesting suggestions about water use efficiency were largely overlooked. The investigation seems to have set out from the start not to learn but to 'succeed'; not, that is, to conduct a scientific investigation of causality, but to show that the chosen intervention made things better. Perhaps it would be fairer to describe it as a privileged pilot project rather than a research study. As a research study, it failed by succeeding.

Islands of Salvation

The 'pilot project syndrome' is well known in rural development. A small area is chosen for its favourable conditions, and an experiment or trial undertaken with special inputs, management, care and attention. It 'succeeds'; lessons are believed to have been learnt; and directives are issued for the approach to be replicated. But the special conditions which enabled the experiment or trial to do well are not reproduced, nor indeed reproducable, and the innovation fails to spread. As with the Koliary chak above, an island of salvation is created which cannot be multiplied into an archipelago, let alone a land mass.

To try to understand this phenomenon, let us examine two other examples: the Mohini Water Cooperative Society near Surat in Gujarat; and the Naurangdeshar Canal System of the Rajasthan Canal Project.

Mohini[2]

Water cooperatives which purchase water in bulk and then distribute it among their members are widely regarded as a promising development deserving support and spread. The India's Sixth Five-Year Plan had this to say:

> Already Gujarat has made an effort in forming farmers cooperative (*sic*) for distribution of water. They take water in bulk from the irrigation department and distribute it amongst the members. This has resulted in better efficiency in use of water. (GOI, 1981, p157)

The Water Technology Centre Study of Mahi-Kadana devoted a whole chapter to irrigation cooperatives and proposed their introduction (WTC, 1983, pp288–297). A senior official, K. M. Dave, also wrote (1983, p127) that:

> The benefits of such water cooperatives have now come to be recognised by one and all. It is a very powerful tool for optimising the returns from the irrigation projects. Moreover, such water cooperatives can also help in bringing out a total change in the status and living conditions of the beneficiaries.

In the first half of the 1980s, water cooperatives, in the plural, were part of the common currency of discussion about farmers' organization on canal irrigation in India, and in 1986 one authority wrote that:

> it has been accepted at all levels that the Water Co-operative offers the best solution for economical and efficient water use and increased productivity (Shah, 1986, p9).

The idea of water cooperatives is not new: they have been proposed in Maharashtra for at least two and a half decades. The Maharashtra State Irrigation Commission recommended in 1962 that the distribution of canal water should be entrusted to cooperative societies of the irrigators. But attempts to trace back the various favourable views about water cooperatives to actual institutions operating on the ground always lead to the same place. Unlike other sources which mentioned cooperatives in the plural, the recommendations of the 1980 Conference on Warabandi (Singh, 1981) were careful to mention only a singular water cooperative in Gujarat as an example of farmers' organizations. This appears accurate, for again and again references trace back to the same institution, the Mohini Water Cooperative Society or Mohini for short. In the WTC Report it is cited as 'the first successful irrigation cooperative in Gujarat' (WTC, 1983, p291). It is described by V. S. Sinha (1983), Area Development Commissioner, Surat, by Pant and Verma (1983, pp23–4, citing Sinha), by K. M. Dave, Superintending Engineer and Officer on Special Duty (1983), and by R. K. Patil. As Dave put it, Mohini 'has made tremendous all round impact and its name and fame have spread not only in the entire state but also in the entire irrigation sector of this country at large' (1983, p133). It was indeed the source of the statement in the Sixth Five-Year Plan (Patil and Datye, 1986, p2).

This cooperative which has so influenced thinking has a good record. Founded in 1978 it was assigned a CCA of about 450 hectares on the Bhestan minor of the Kakrapar canal system, and began with 145 members. Over the years its membership, area and intensity of irrigation grew. The government wholesaled water at

30p per 10,000 litres to the society which then sold it to its members on a per acre basis with a substantial margin. Its members benefited and the society became an instant success (Patil and Datye, 1986, p4).

This success, and these benefits, were, though, based on special and privileged conditions. The cooperative had strong leadership. Seventy per cent of members were Patels, reputed to be commercially astute. Location was favourable: the society is close to Surat city, a national highway, and the Chalthon Sugar Mill. There was special government help: at the outset, the distribution network of canals was renovated at government expense, additional outlets to the minor were added, vulnerable reaches even of water courses were lined, and 'all preliminary procedures were set up for smooth interaction with local officers of Government for all matters' (Dave, 1983, p132).

For the first three years the state government provided a manager, a supervisor, and two clerks and agreed to reimburse any net loss.

There was also exceptional access to high-level staff, with solutions to problems worked out at the deputy executive engineer and executive engineer (EE) levels (Shah, 1986, p13). Although the designed crop pattern limited the area of the profitable crop of sugarcane to only 18 per cent, the actual area in Mohini Command exceeded 85 per cent (Patil and Datye, 1986, p4).

When a high-powered task force visited the Kakrapar Command in 1983, the cooperative visited was almost certainly Mohini. The task force chairman, S. P. Mukerji, the Secretary of Agriculture, wrote:

> Much has been talked about the water cooperatives in this Command. Unfortunately, we were not very much impressed by our visit and discussions with the members of a water cooperative society. The cooperative covers only 440 hectares around a sugar mill and most of the area has been brought under sugarcane... The cooperative has been a method by these farmers to obtain water in bulk at a concessional rate and distribute the same amongst the members for production of sugarcane under the overall protective umbrella and support of the local sugar mill. (MOA, 1984, p64)

The low water rate and the heavy reliance on sugarcane gave both society and farmers favourable financial margins. Perhaps, most important of all, before the society was formed, irregular water supplies from the main system adversely affected farming, but with the society a reliable and adequate supply was assured. Indeed, it would have been an unusually imprudent EE or Deputy EE who did not go to pains to ensure a good water supply to an area which attracted such frequent visitors and so much national attention.

An impression easily grew that there were other functioning water cooperatives like Mohini. V. S. Sinha (1984, p264) reported the registration of a second cooperative, the Dhanori Changa Piyat Sahakari Mandli, and a demand in 1982 for 37 more. In 1986, 21 water cooperative societies were reported to have been registered in the Ukai-Kakrapar Command Area, and two were said to have started functioning in 1985 (Shah, 1986, p14). But one authority, while supporting the propagation of irrigation cooperatives, observed that the Maharashtra Government had pursued the issue of handing over water to cooperative bodies of irrigators for 30 years but 'still full success is not in the offing' (Gandhi, 1985, p14); and others were more directly sceptical. Patil and Datye (1986, p2) wrote that the Mohini Society 'has not been replicated and 20 societies registered in the vicinity are virtually defunct'. That this could be so is scarcely surprising. The location and history of Mohini make it a classical case of the pampered pet project, where each special measure reduces replicability. The levels of subsidy, of sugarcane cultivation, of high-level official concern for success, and especially of assured water supply, were not easy to repeat. Mohini, much visited and much mentioned, generated a myth of water cooperatives in Gujarat. But it probably has been, and may well remain, alone, an island of salvation.

In its section on Command Area Development, the Seventh Five-Year Plan has farmers cooperatives again in the plural, assumes replicability and advocates their spread:

> The farmers' associations and cooperatives established in some parts of the country have been successful in the equitable distribution of water among their members, the bulk of the water supply being given by the Irrigation Department, to such cooperatives. This must be extended to other areas. (GOI, 1985, pII:82)

Outside India, Mohini has been generalized to Gujarat State as a whole. One international authority wrote in 1986:

> In Gujarat State in India, the irrigation agency sells water volumetrically in bulk to cooperatives, which distribute it and collect fees from their members (Repetto, 1986, p33)

The myth of water cooperatives in Gujarat has, it seems, an ability to spread not shared by the institution itself. It is believed in Washington as well as New Delhi. Just how immortal the myth is will be shown in the Eighth Plan, to be awaited with keen interest.

Naurangdeshar

In 1980 a long-term improved water management study was taken up in an area of about 28,000ha under the Naurangdeshar Distributary of the Rajasthan Canal (Bithu, 1983). Water flows and deliveries were measured and monitored at 21 main take-off points on distributaries and minors and at 20 tailend points on the minors and subminors. Irrigation demonstration fields were established. Special 0 and M grants were made to improve operation and maintenance. Irrigators in the area were occasionally contacted by water management staff to assess equitability of irrigation water distribution and crop production.

The trial area did better than a control area. Cropping intensity was higher in the trial area – 66 per cent against 47. More wheat, mustard and cotton were grown, while gram, the lower risk lower value crop, was grown more in the control. The programme in the Naurangdeshar distributary system was said to be widely accepted and acclaimed by the irrigators.

The better performance of the trial area was, however, at the expense of the rest of the system. Water deliveries to the Rajasthan canal from Punjab were not regular, and fluctuations in canal water deliveries were 'occasioned by the unpredictable monsoon and lack of systems approach by the interstate irrigation promoters' (Bithu, 1983, p74). Efforts were made to ensure timely and adequate supplies from Punjab, but 'in the meantime certainty of water delivery in Naurangdeshar distributary system [had] been ensured through preferential running of the system'. In his analysis, Bithu notes the connection between the trial performance and this preferential treatment, and concludes that 'since preferential running of all systems on demand is not possible unless we ensure adequate and assured supplies from Punjab, its extension to other systems is limited for sometime' (Bithu, 1983, p77). The point can be taken further: if one part of the system receives guaranteed adequate and timely water when overall supplies are variable and unreliable, then untimeliness and inadequacy are amplified in other parts of the system. Naurangdeshar's performance must have had costs elsewhere. It is perhaps unsurprising that there was a general consensus among farmers that the system should be extended. Farmers will always go for a preferential water supply.

Learning and Mislearning

These cases throw light on learning and mislearning about canal irrigation, and point to pitfalls. Four further observations can be made.

First, areas chosen for action research or pilot projects are often specially favoured. Like the Koliary chak, they may be in the head reaches. Like both Koliary and Mohini, they may be close to administrative headquarters. Conversely, controls are often in less-favoured areas, as happened with the MRP and HRP controls.

Second, special attention makes it difficult to draw practical conclusions. One reason is multiple causality. If there are several interventions, and yields are higher, then there are several explanations. The higher yields on the Koliary outlet could be attributed to combinations of special supplies of the following: credit, HYV seeds, fertilizer, pesticides, extension and water. Another reason is privileged access to water at the cost of other parts of the system. The Koliary outlet and the Naurangdeshar Distributary were both given specially adequate and reliable water supplies from larger systems where other reaches already had inadequate and unreliable supplies. In this, they were not unusual. Again and again, when an initiative – whether described as action research, or pilot project, or experiment – is probed, it emerges that it has been favoured for water. This may be a deliberate part of the treatment, as with Koliary and Naurangdeshar; or it may be unintended, where system managers give a better than usual supply to a part of their system where they know investigations are taking place.

Such a supply usually has costs elsewhere. Digby Bevan (personal communication) visiting a warabandi pilot project in Andhra Pradesh in 1980 found, through his initial questioning, that the farmers were happy and everything appeared to be running smoothly; but further investigations revealed that the pilot scheme was getting preferential treatment and receiving more water than needed while the supply in the larger area of which the scheme was part was completely erratic. P. S. Rao (personal communication) visiting a pilot project for rotational water supplies on part of the Periyar Vaigai Project in Tamil Nadu went further down the minor and found farmers who complained that they were getting less water than before as a result of the pilot project. Anthony Bottrall (1983, p106) found that farmers in a village immediately downstream of a pilot (showpiece) watercourse were receiving very little water because extra supplies were being diverted to the pilot watercourse in order to demonstrate its 'success'. Similarly low concentrations of wheat, mustard and cotton on the Rajasthan Canal control, and its higher concentrations of gram, probably owed something to the adverse effects of the privileged water supply of the Naurangdeshar Distributary.

So, wherever research or a pilot project is undertaken and 'success' reported, whether it is warabandi, on-farm development, canal lining, farmers' organization, rehabilitation, the management of minors or distributaries or something else, costs to other parts of the system must be assessed. The question is whether water to the special area means supplies to others, which are smaller, are less timely and less predictable. Islands of salvation often draw resources to themselves and deprive others. Many successes are really failures. Nor are they replicable unless water supplies on the main system can be managed to provide a similar supply elsewhere. Once again, analysis points to the priority of main system management.

Third, the normal process of learning from 'islands of salvation' can mislead. The biases of rural development tourism (Chambers, 1983, pp10–25) apply. Short visits by officials and researchers give rise to insights of uniform superficiality. The same farmers are met by a succession of visitors and they tell them the same things, while others are not met. What the farmers say can be slanted, sometimes false. A social anthropologist in South India once sat through a whole morning during which officials put farmers through their lines, rehearsing them in how to answer questions expected from a senior officer who was coming the next day. Then visitors are taken to the best places, and do not have time, even if they wish, to probe multiple causation, to question biases in what they see or are told, or to perceive costs to other places which offset the benefits they are shown. With any policy – CADA, OFD, 8 hectare chaks, warabandi – rural development tourism and the well-prepared visit impede learning and distort perceptions. Visitors depart to their conferences and committees where error reinforces error as they repeat to each other their common misperceptions. As with the Mohini Cooperative, a belief can gain currency that an approach is replicable and should be included in policy and plans. Busy politicians and policy makers need good ideas to seize on and push, but all too often these are based on and support self-sustaining myths.

Truth is elusive, and as Oscar Wilde said, never pure and rarely simple. To get closer to it requires awareness of these traps, and commitment to good research.

Reflections on Research

Good research is difficult. It is easiest to do professionally acceptable research by sticking to narrow topics. Those who branch out into more complex investigations like action research face methodological problems and will be open to criticism from colleagues. Yet these risks have to be accepted if gap and linkage subjects are to be opened up and if fuller and more balanced understanding is to help improve performance.

Two sets of considerations appear important here. First, what determines what research will be done, and in particular what deters research on gaps and linkages. Second, what approaches and qualities are required from those who undertake it.

Determinants of research

The many determinants of research include fashions and funding, who is available, and researchability.

Worldwide, rural research tends to follow the latest fashions and priorities of funding agencies, and these often follow the latest programmes of government. Canal irrigation in India is no exception. Thus, on Mahi-Kadana, Asopa and Tripathy studied the Command Area Development programme soon after it had come in; the WMSP team operated mainly below the outlet, which was also where government programmes (OFD, farmers' organization and warabandi) had concentrated; and the WTC research, in its objective, was concerned with total resource use, moving in the direction of mounting official concern with poor canal irrigation system performance. The WAPCOS research was even more directly linked with policy, intended as it was to test the benefits of a proposed large-scale programme.

But good research does not necessarily have to be linked to immediate policy or innovation. Investigations which simply (or not so simply) show what is happening to water, crops and people, have much to contribute. Those organizations, whether government or private, which fund research, do well to achieve a balance between studies which monitor and assess current performance and programmes, those which more directly investigate future opportunities, and those which open up gaps and linkages. The tendency is for current programmes to be studied, and for gaps and linkages to remain unresearched, as blind spots.

What research is undertaken is also determined by who is available. Research is often thought to be led by demand. Government, public corporations, universities and foundations determine priorities and then fund researchers to follow them.

This is only part of the truth. What can be done depends also on who is available and on their interests and skills. Research on canal irrigation in South Asia has until recently been conducted almost exclusively by physical and biological scientists. In contrast, in India in the mid-1980s, the Indian sociologists committed to field research on canal irrigation could still be numbered on the fingers of one hand. The neglect of the human and managerial domain can be attributed more to a lack of supply – of researchers – than to lack of support for them to conduct research. In this respect, the WTC study did not muster a sociologist, and, perhaps as a consequence, did not deal with farmers' actual organization or distribution below the outlet. In contrast, the Asopa/Tripathi and WMSP studies were exceptional in the attention they gave to social aspects of irrigation.

To a damaging degree, researchability also determines what is researched and so what is known. Inconvenience deters senior researchers from sustained field measurements. Water flows are anyway difficult to measure accurately. Flows at night, that most inconvenient time, remain largely a black box. Or again, corruption can affect system performance, but is a sensitive subject which cannot be explored by a quick field visit, and even less by stating that it is to be investigated. It is not surprising that the Mahi-Kadana studies did not go in any detail into whether or not payments were made by farmers in order to obtain water indents, and how this hassle and cost factor might have influenced their irrigation decisions. It is far easier for an agricultural economist to investigate input or farmgate prices than to assess the significance of a hassle factor in deterring farmers from applying for water, or for an agricultural engineer to record frequency of damage to watercourse structures than to measure water flows at night. Moreover, for gap and linkage subjects, there are often no clearly established methods of inquiry. How, for example, does one assess the knowledge and expectations of farmers regarding the water they will receive from the main system, and how this affects their behaviour? Crucial though this may be for farmer's behaviour, it is not studied or reported on. Some difficult subjects are all the more important because less is known about them.

Approaches

This leads straight to the approaches of researchers. It is easy to say what ought to be done, but harder to do it. Nevertheless, three approaches or qualities can help to offset biases, to explore gaps and linkages and to achieve balanced insight. These are an open learning process, a concern for understanding and truth, and introspection.

An open learning process approach to research is often made difficult by funding and methods. To obtain funding, a research design is often called for. Preparing it can be salutary, injecting realism into plans. But a blueprint mentality and a rigid method can damage and constrict. One great drawback of research by blueprint, on familiar topics using well-worn methods, is what it excludes. Preset questionnaires are barriers to learning. Standard surveys, in whatever subject, provide standard information and exclude the unexpected. When method is the master, gaps, linkages and serendipity stay in the dark. Standard multidisciplinary research can generate islands of information between which bridges cannot be built.

On the other hand, inquisitiveness, observation, and an eagerness to learn from farmers and others can open up unsuspected topics. For example, the WMSP finding on Mahi-Kadana that farmers were prepared to pay seven to nine times as much for lift irrigation water as the official water rate for canal water might have suggested a new research agenda with new policy implications.

There is no one recipe for an open learning process, and more depends on attitudes than on planning. But one measure can be recommended: not committing all research resources at the start of an investigation. If spare capacity is held in reserve, new questions can be followed up as and when they are identified. This is not to argue against careful measurements sustained over time. It is to argue that they are unlikely to be enough in themselves, and that qualitative investigations, often with improvised methods, have much to contribute if gaps, linkages and serendipity are to be explored as they need to be.

It seems obvious that concern for understanding and truth should drive every researcher. Yet routine performance of a method and a stereotyped report often seem to reflect concern more for proper observance of ritual than for new knowledge. One omission in most, perhaps all, disciplines is self-critical publication by researchers of defects in their methods. When researchers honestly present the errors and limitations of their research, it gains in credibility, and the confessions contribute to future methodology. Research is not a ritual, still less an exercise in producing a predetermined right answer. It is, or should be, an exploration of unknown terrain where one does not know what will be found. Canal irrigation is so shrouded in mists of misinformation that it needs many more who keep their eyes open and report what they see. Action research is thick with traps (Chambers and Lenton, 1981), and temptations to make pilot projects islands of salvation are hard to resist. The best service is done by those who strive not for correct appearances but for true insight.

Finally, observers do not often observe themselves, or assess the limits of their vision. Little research is conducted on research. Yet so often researchers see what they are trained to see, ask what they are trained to ask, measure what they are trained to measure, and conclude what they are trained to conclude. This has its value, within limits. But many of the more important aspects of canal irrigation are simply not covered in textbooks or training. Though knowledgeable and competent in their subjects, well-trained professionals miss much that matters. Normal professionalism is not enough. Few would perhaps disagree. But to extend normal professionalism to cover gaps and linkages is hard. A first step is awareness of one's conditioning and biases. It is easy to be deterred from exploring new domains, hidden linkages, and gap subjects, not just by inconvenience or risk, but also because vision is confined and directed by the ruts and reflexes of disciplines. Introspection is one way of removing such professional blinkers, gaining a wider view and offsetting biases.

Notes

1 It was also compared with the 57 general outlets, for which the same method of analysis was used as for the 11 controls (giving low 70, high 117, average 100).

2 I am grateful to R. K. Patil for personal communications derived from his field work which have shed much light on Mohini and water cooperatives. See also Patil references. Responsibility for the views expressed is, however, mine.

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Part II

Participatory Processes

6

Reversals, Institutions and Change

Robert Chambers

Farmer first and TOT

The new behaviours and attitudes presented by the contributors to this book conflict with much normal professionalism and with much normal bureaucracy. Normal professional training and values are deeply embedded in the transfer-of-technology (TOT) mode, with scientists deciding research priorities, generating technology and passing it to extension agents to transfer to farmers. Normal bureaucracy is hierarchical and centralizes, standardizes and simplifies. When the two combine, as they do in large organizations, whether agricultural universities, international agricultural research centres, or national agricultural research systems (NARSs), they have an impressive capacity to reproduce themselves and to resist change.

But to serve well the resource-poor farm families of the third – complex, diverse and risk-prone – agriculture with which much of this book has been concerned, requires these 'normal' tendencies to be reversed: for farmers' analysis to be the basis of most research priorities, for farmers to experiment and evaluate, for scientists to learn from and with them; and for research and services to farmers to be decentralized, differentiated and versatile.

The difficulty of effecting major changes and reversals in large organizations underlines the importance of seeing what changes of behaviour and attitude are required, what institutional conditions are necessary for them to be sustained and spread, and how these might be achieved. To do this, we need to outline in more detail the contrast between TOT and the farmer-first approach and methods represented in this book (see Table 6.1).

With farmer first, the main objective is not to transfer known technology, but to empower farmers to learn, adapt and do better; analysis is not by outsiders – scientists, extensionists or NGO workers – on their own but by farmers and by farmers assisted by outsiders; the primary location for research and development

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Table 6.1 *Transfer of technology and farmer-first compared*

	TOT	*FF*
Main objective	Transfer technology	Empower farmers
Analysis of needs and priorities by	Outsiders	Farmers assisted by outsiders
Primary R&D location	Experiment station, laboratory, greenhouse	Farmers' fields and conditions
Transferred by outsiders to farmers	Precepts Messages Package of practices	Principles Methods Basket of choices
The 'menu'	Fixed	À la carte

(R&D) is not the experiment station, laboratory or greenhouse, necessary though they are for some purposes, but farmers' fields and conditions; what is transferred by outsiders to farmers is not precepts but principles, not messages but methods, not a package of practices to be adopted but a basket of choices from which to select. The menu, in short, is not fixed or table d'hôte, but à la carte and the menu itself is a response to farmers' needs articulated by them. All this demands changes in activities and roles.

Farmer-first Activities and Roles

Contributions to this book show farmers carrying out or participating in various activities which in the TOT mode are conducted only by scientists. Three of these, again and again, are analysis, choice and experiment. To support farmers in these activities generates and requires new roles for outsiders:

Farmers' activities	*New roles for outsiders*
analysis	convenor, catalyst, adviser
choice	searcher, supplier, travel agent
experiment	supporter, consultant

What these activities and roles entail can be illustrated by contributions to this book, supported by other sources.

(i) Analysis. Analysis by farmers takes many forms and can be promoted in many ways, involving outsiders to different degrees. In the examples in this book an outsider has often played a role, whether as questioner, convenor of a group, stimulator of discussion or catalyst whose presence speeds up the process.

Analysis can be part of or generated by the use of a method. Some examples are:

- open interviews and iterative group conversations (Floquet, 1989);
- ethnohistory and ethnobiography (the biography of a crop, or of a person's experience of a crop, an historical analysis of the experience of a community etc.) (Box, 1987);
- inspection and discussion: visiting trial sites, observing innovations, field days, and visits by farmers to research stations when they observe and discuss (Ashby et al, 1987);
- visual aids to analysis: seasonal and other diagramming (Conway, 1985), aerial photographs (Carson, 1987), systems diagramming on a board (Lightfoot et al, 1987), other uses of diagrams with and by farmers and communities (Kabutha and Ford, 1988; McCracken, 1988) and drawing maps (Gupta, 1987a, b);
- eliciting clients' criteria and preferences, where individuals or groups (women, men, farmers etc.) articulate their reasons for preferences, and then rank items according to them (Ashby et al, 1987; Chambers, 1988);
- key questions and approaches to questioning: 'ways in' or 'points of entry' such as 'What would a desirable variety look like to you?' (Ashby et al, 1987, p27), 'What would you like your landscape to look like in the future?' (Rocheleau et al, 1985), 'When you were a boy, what was the oldest variety of (a particular crop) that you knew about?' (Box, 1987) and 'Comparing agriculture practiced at the time of your father and grandfather with the agriculture practiced by you today, what are the major changes that have occurred?' (Gubbels, 1988);
- contrast analysis, where groups or individuals are asked to explain the contrasting conditions or behaviour of others, thus setting a frame of reference before analysing their own (Gupta, 1987a, b)
- sequences of meetings and visits (Rocheleau et al, 1985; Mathema and Galt, 1987; Lightfoot et al, 1987; Repulda et al, 1987; Norman et al, 1988);
- innovator workshops where farmer innovators meet to discuss their new practices (Abedin and Haque, 1987; Ashby et al, 1987).

The role of the outsider is to elicit, encourage, facilitate and promote analysis by farmers, providing where necessary the stimulus, the occasion and the incentive for meetings and discussions. The outsider can take part, but does not dominate. Farmers' own analysis, criteria and priorities come first. Requests are generated for outsiders to search for what farmers want and need, and to provide them with choices or ideas for experiments to solve a problem or exploit an opportunity (Lightfoot et al, 1987; Repulda et al, 1987).

(ii) Choice. Choice by farmers is prominent in the farmer-first paradigm. It has two aspects. First, farmers' analysis generates an agenda of requests for information and material. Second, farmers need a range of choice, so that they can pick and choose to suit their conditions, extend their repertoire and enhance their adaptability. Norman et al note 'the technology assessment process in which a wide range of options are presented to a large number of volunteer farmers' (1988, p141). To find and present variety and choices to farmers is largely a task for outsiders. Some examples are:

- providing farmers with varied genetic materials to test and appraise (Ashby et al, 1987; Norman et al, 1988);
- planting a variety of lines or species, to be followed by 'wait-and-see and pick-and-choose';
- issuing mini-kits of seeds and fertilizers to farmers for them to try out in various combinations;
- requiring nurseries, as with forestry in Kenya, to plant and provide a range of species, including a preponderance of indigenous species;
- transferring genetic material between regions, countries and continents, especially of non-cereal plants (multi-purpose trees, shrubs, grasses, vining plants, root crops etc.) and livestock;
- transferring indigenous technical knowledge and practices between farmers in different regions;
- enabling farmers to travel, visit, see and learn for themselves the farming practices of others.

The role of the outsider, whether scientist, extensionist, or NGO worker, is to search for and supply the species, varieties, treatments, cultural practices, scientific principles or combinations of these which fit and meet farmers' requests and needs. It may also be that of travel agent or tour operator, to arrange for farmers to visit research stations, other farmers, or other regions, to learn from other farmers and scientists and to widen their experience and options.

(iii) Experimenting. Experimenting by farmers has long been under-perceived. The professional world has been slow to recognize farmers' experimental inclinations and abilities (but see Johnson, 1972; Richards, 1985; Rhoades, 1987). Rhoades and Bebbington (1988) have identified three reasons why farmers experiment: to satisfy curiosity; to solve problems; and to adapt technology. As we have seen, their farming is both performance (Richards, 1987) and in a sense a continuous experiment: Hossain et al point out that farmers in Bangladesh are continually changing their cropping patterns (1987, p35) and Juma puts it that 'a farmer is a person who experiments constantly because he is constantly moving into the unknown' (1987, p34).

In the farmer-first approach, it is not packages of technology that are provided to farmers, but genetic material, principles, practices and methods for them to test and use. Genetic material can take many forms and may come from nearby, from other regions, or from other countries or continents. Similarly, principles can originate from different sources: in West Africa, the principle of alley cropping was taken from the research station and was adapted and experimented with by farmers (Sumberg and Okali, 1988); the principle of diffused light to inhibit potato sprouting in store originated with farmers in Kenya and was spread internationally and laterally to other farmers in many countries, who made their own applications with local materials to fit local farm architecture (Rhoades, 1987). Experimental principles and methods suitable for their conditions and needs can also be provided to farmers to improve their investigations and innovations (Bunch, 1985, 1987).

Farmers' experiments are, then, encouraged and supported by outsiders. This is close to Biggs' collegiate mode of farmer–scientist *interaction*. Farmers take part in design (Fernandez and Salvatierra, 1987), determine management conditions and implement and evaluate the experiments. They 'own' the experiments and the outsiders provide support and advice.

Evaluation of experiments is also by farmers and continuous. An authoritative World Bank publication (Casley and Kumar, 1987, p116) has pointed out that it is often assumed that illiterate, tradition-bound farmers cannot assess the dynamics of change, but that their knowledge and judgments are in many instances more accurate than those of project staff. One of D. M. Maurya's criteria for assessing a line given to a farmer to try is whether other farmers ask for seed (personal communication). It is farmers' judgements, interest and adoption that count.

Stimulating, servicing and supporting these farmers' activities – analysis, choice and experiment – requires reversals of normal and expected roles on the part of outsiders, be they scientists, extensionists or workers in NGOs. This does not mean that they have to be purely passive catalysts. It would be as absurd for their ideas and knowledge not to be brought into play, as it has been for those of farmers to be neglected. In raising questions, in providing tools for analysis, in presenting what they already know to be feasible and available choices, and in supporting and advising on farmers' experiments, they have a part to play. But their role is not that of teacher, of the bearer of superior modern technology, of the person who knows what is good for others better than they know for themselves. It is neither the role of traditional agricultural extension, nor that of normal agricultural science. An open, learning process approach is indicated, of a sort encouraged neither by the content of university curricula nor by the hierarchy and style of government bureaucracies.

For these changes and reversals of role to occur on any scale is not easy. It requires resolute changes in institutions, in incentives and in methods and interactions.

Institutional Change

Unfortunately, normal bureaucracy tends to centralize, standardize and simplify, and agricultural research and extension are no exceptions. They fit badly, therefore, with the conditions of resource-poor farm families, with their geographical scatter, heterogeneity and complexity within any farm and farm household. In resource-rich areas of industrial and Green Revolution agriculture, production has been raised through packages, with the environment managed and controlled to fit the genotype. The third agriculture, being complex, diverse and risk-prone, requires the reverse, with searches for genotypes to fit environments. In industrial and Green Revolution agriculture, higher production has come from intensification of inputs and simplification and standardization of practices; in the third agriculture, it comes more from diversifying enterprises and multiplying linkages. Green Revolution agriculture has been convergent, evolving towards common practices; the third agriculture often needs to be divergent, evolving towards a greater variety of differing enterprises and practices.

At first sight, then, the farmer-first approach appears incompatible with normal bureaucracy. But as contributors to this book have shown, reversals in government research organizations, though difficult to start and to sustain, are not impossible. Some contributors were working in special projects linked with NARSs; others were working in more normal conditions, as with the innovator workshops in Bangladesh (Abedin and Haque, 1987) and the distribution to farmers of advanced lines of rice in India (Maurya and Bottrall, 1987).

For the future, to achieve farmer-first reversals in national bureaucracies, especially NARSs, three aspects of management merit special attention: decentralization and resources; search and supply; and incentives.

(i) Decentralization and resources. Central controls need loosening if local actions are to fit diverse conditions. Centralized permissions for expenditures constrain flexibility. Centrally coordinated trials limit discretion and the ability to serve local priorities. When resources such as transport and money for travel are scarce, local discretion and control become more important than ever. The essence of farmer-first approaches is to serve and support local diversity, with a reversal of demands on staff, the demands to come from farmers below more than from seniors above.

Decentralization is difficult in normal bureaucracies. Central accountants fear loss of control over expenditures. Central officials fear loss of power and prestige. Reports are harder to collate and present, and work harder to supervise, when activities are varied. Methods are needed, perhaps easier now with microcomputers, for valuing local diversity in staff activities in place of counting reported achievements of standard targets. For NARSs, the practical implications are to devolve resources and discretion more to the local level.

Freedom and means for staff to visit and spend time with farmers are crucial. For travel, something can usually be done quite simply. In the joint trek in Nepal, scientists walk together for days (Mathema and Galt, 1987). Foot, bicycle, horse and public transport can, variously, be used. For cost-effectiveness, though, other means of travel can be important, especially when distances are great and environments diverse. Unfortunately, access to transport and permission to use it are frequent problems, though less so with foreign-funded programmes. Travel and allowances can be high-profile privileges for which staff compete, jealously guarded and sparingly allocated by directors of institutes and heads of units. Worse, when revenue shortfalls or national policy reforms force cuts in recurrent budgets, staff are usually protected and it is other votes that suffer. Fuel, vehicles and nights out allowances are favourite victims. In Zambia, the Ministry of Agriculture's vote for petrol and maintenance had been reduced by 1980 to only one fifth of its 1973 level despite an increase in vehicles and staff (ILO, 1981, pxxvi). Scientists can usually work with farmers close to their research stations and residences; but without hassle-free and adequate access to means for travel, it is difficult for them to work regularly and well with others further afield.

(ii) Search and supply. Search is neglected and rarely rewarded as a professional activity. This includes search for farmer-innovators and experimenters, for genetic material, and for principles, practices and technologies, whether locally, regionally, nationally or internationally.

Search is basic for meeting farmers' needs and widening their choices. In complex, diverse and risk-prone agriculture, what farmers want and need often differs from the simplifications of centrally planned priorities. Agricultural research and extension have, for example, a tendency to specialize on single commodities. But farmers' analysis will often specify a non-commodity need, such as multi-purpose trees for agroforestry, or a rapidly vining legume to suppress weeds, or a range of vegetable seeds, or means to create, improve and exploit micro-environments, or technology for harvesting water, capturing and concentrating soil, or improving the supply of plant nutrients. As a result of past neglect, the potential for search and supply of such varied material and technologies seems still very large.

Search and supply have institutional implications. These include that grassroots extension staff and scientists have resources and are rewarded, for finding farmers' innovations and experiments and for stimulating and articulating realistic demand from farmers; and an ability of national and international agricultural research systems to respond with supplies of genetic material, principles and methods.

These reversals face two major obstacles. First, extensionists and scientists may not be rewarded for raising problems and making requests. Extensionists seen in the TOT and normal bureaucratic mode are there to pass on messages and packages downwards, not to multiply work for their senior officers by passing varied requests upwards. Second, most NARSs lack capacity to respond to needs and requests articulated by farmers for material or information. In practice, most management information systems are designed to feed information upwards to serve central management, rather than to draw it downwards to serve farmers. Six of the seven management information systems listed in 1987 for agricultural research in the Philippines were for central management; only one, the Research Information Storage and Retrieval System, was to provide information useful at the grassroots, and that was described in the future tense, with the statement that financial support was needed to extend it into the regions. Many NARSs have poor institutional memories for research findings (see e.g. Kean and Singogo Lingston, 1988, p48), and work often has to be repeated because earlier records cannot be found. Few, if any, are yet set up well enough to provide diverse information, genetic material and technologies to meet diverse local demand.

The practical implications are for agricultural research and extension organizations to make three changes: to encourage field staff to search for, support and spread farmers' innovations; to judge and reward staff by the requests they make upwards in response to analysis and demands by farmers; and to develop information and supply systems to respond to those demands.

(iii) Incentives. As with any new paradigm, professionals who innovate in the farmer-first mode risk being marginalized. In the short term, the safest route to promotion will often seem to be work on-station not on-farm; on irrigated agriculture, not rainfed (and least of all on unreliable rainfed); on a single commodity, not complex combinations; on industrial, commercial and major cereal crops not low status subsistence food crops; with quick maturing annuals not slow maturing perennials like shrubs and trees; and with validation through standard experimental design not farmers' adoption. Nor does improving complex, diverse and risk-prone (CDR) farming lend itself to the statistical testing methods taught in textbooks, involving as it often does complex and multiple simultaneous change, for example, agroforestry combined with water harvesting, growing fish with rainfed rice, home gardening with several canopies, or the creation and exploitation of protected micro-environments in semi-arid conditions. More papers can be produced more reliably by using conventional methods on conventional crops in conventional environments, where there is already a good information base, than by using unconventional methods on unconventional agricultural practices in unconventional environments. Where promotions boards judge candidates only by adherence to standard methods, or numbers of publications, rather than farmers' adoption, then pioneers in farmer-first modes will not do as well as their less innovative colleagues.

The rapid transfer of agricultural research staff poses a further problem especially in sub-Saharan Africa. The costs in lost continuity and effectiveness in formal on-station research are well known. Less well recognized is the way in which rapid turnover reduces incentives for staff to build up relations with farmers, and undermines farmers' confidence in them.

The practical implications of these obstacles are to develop enabling conditions and incentives. The several forms these can take include the following:

- assessing research staff less on publications, and extension staff less on the achievement of targets; and both more on the demands and searches they initiate on behalf of farmers, on farmers' interest and innovation and on adoption and spread of technology;
- rewarding those who pioneer and write about new methods. Until recently, farmer-first research methods were not much the subject of articles in the harder scientific journals, but as the summer 1988 issue of *Experimental Agriculture* (Farrington, 1988) has shown, this is changing. As scientists come to realize that they can publish articles about their methods and experiences, and that these bring national and international recognition, publishing disincentives should not just disappear but be reversed;
- ensuring more continuity for scientists in field posts. This may be difficult for many reasons. Fortunately, where lack of staff continuity is endemic, experimenting farmers and local organizations may be able, more and more, to provide their own continuity;
- networking between farmer-first researchers, providing mutual support and recognition.

The strongest incentive, though, is professional and personal satisfaction. Those who make reversals and changes in directions like those in this book, and who work collegially with farmers, soon find it intellectually and professionally exciting, enjoyable, and even fun, with the supreme reward of effectively helping farmers to do better. This is the most hopeful aspect. For even if other conditions are adverse, more and more will want to work in the farmer-first mode for the simple and sound reason that it satisfies and succeeds.

Methods and Interactions

In themselves, these three things – decentralization and resources, organization for search and supply, and providing incentives – are not enough. Much also depends on what is done and how it is done – on the methods available and the quality of interactions.

The need here is to develop further, describe and disseminate farmer-first methods in detail. Just as the aim is to widen choice of practices for resource-poor farmers, so it is to widen choice of methods for scientists and extensionists. Some of these are methods for decentralization, for search and supply and for farmers' experiments; yet others are for interactions between professionals and farmers. Many such methods are now known. Those that are most promising deserve to be evaluated, written up and made accessible through manuals and practical training.

The more important methods to be developed and described include:

- aiding farmers' analysis and learning their agendas;
- getting started with families and communities;
- finding out about agricultural research (for NGOs);
- finding and supporting farmers' experiments;
- convening and assisting groups;
- convening and managing innovator workshops;
- searching, and supplying farmers with what they want and need;
- designing and managing incentives for scientists;
- communicating: farm family and outsider face to face.

This last, concerning the quality of interaction between farmers and scientists, is as crucial as it has been neglected. Most accounts and manuals concentrate on the mechanics of methods, as though rules guarantee results. This is not so. As social anthropologists, sociologists and some psychologists know, and as is only common sense, the quality of the face-to-face relationship can make or mar an interview or discussion; and much depends on mutual respect and rapport.

Good advice is available (see e.g. Rhoades, 1982; Grandstaff and Grandstaff, 1987) but one may still ask how many scientists and extensionists have a grounding in the significance of non-verbal cues, of seating arrangements, of demeanour and manners and of that respect for and interest in people and what they have to show and say which makes for free and open communication.

Even good manuals and training for farmer-first methods and manners cannot by themselves guarantee good results. After institutions, incentives and interactions, there remains personality. Personal styles and aptitudes differ. The contrast between the closed blueprint approach to development and the open learning process (Korten, 1980, 1984) parallels the contrast between TOT and farmer first. Some people are more at home with blueprints, with fixed plans and rules, and with clear ideas of what is expected and what will be officially rewarded. For them, the TOT mode fits better. Others are more at ease with learning processes, with open-ended exploration, with deciding for themselves how to proceed as they go along, and with the reward of knowing in themselves that they have done well. They will be better with the farmer-first mode.

A Pluralist Strategy

For farmer-first reversals, pluralism is one key to effective action. Individuals have different inclinations, aptitudes and opportunities, and these change over time. Organizations have different potentials, and these vary between countries, regions and environments, and also change. There is no standard situation and no one formula, but there are questions of where to start.

Besides NARSs, the obvious natural leaders at first sight are the International Agricultural Research Centres. They are seen as prestigious sources of innovation, and they set standards for agricultural research. They train many of the more able national scientists. Their publications are easily available and widely consulted. They do, though, have disadvantages. At least one centre (ICRISAT) has a mandate which is said to impede on-farm and with-farmer technology generation. The number of non-economist social scientists is everywhere low, and sometimes derisory. Many of the centres' staff do not speak local vernaculars and so cannot listen directly to farmers. Excellent facilities, normal professional aspirations and high status frontiers such as biotechnology, combine to hold scientists at the central research stations and out of contact with farmers. To their credit, CIP (the International Potato Centre) in Peru and CIAT in Colombia have pioneered and popularized farmer-first methods and some staff at the International Rice Research Institute (IRRI) in the Philippines are active. But the numbers of staff involved are still small, and it remains to be seen how far and fast they and others can go. For the present, the powerful influences of the international centres mostly reinforce the conventional TOT paradigm. The centres are still more of the problem than of the solution. But they need not remain so. With a new vision and understanding, they could lead in developing, improving and spreading the farmer-first approach and methods.

Agricultural universities and faculties, and management institutes which train scientists and extensionists, are another focus for change. Some universities are bastions of conservatism, doggedly reproducing narrow professionalism in their students. Others are more open and innovative. By changing their curricula and teaching, by rewriting their textbooks and by introducing learning from and with farmers, universities and training institutes could help mould and transform the values and behaviour of new generations of scientists and extensionists.

Given their influence, size and coverage, these large organizations – International Agricultural Research Centres, NARSs, national agricultural extension organizations and universities and faculties – must in the longer term be transformed if the gross imbalance between TOT and farmer-first is to be corrected. To achieve this on their own, in isolation, would be difficult though. Fortunately, three other, smaller-scale, types of organization and arrangement provide more favourable environments for reversals and change. These are projects, NGOs and farmers' organizations.

Special projects, working in various combinations with NARSs, are well represented by the contributions to this book: the Agricultural Research Planning Teams in Zambia (Kean and Singogo Lingston, 1988), the Agricultural Technology Improvement Project in Botswana (Norman et al, 1988), the Tropsoils Project in West Sumatra (Colfer et al, 1985), the Agricultural Research and Production Project in Nepal (Mathema and Galt, 1987) and the Farming Systems Development Project in the Eastern Visayas in the Philippines (Lightfoot et al, 1987; Repulda et al, 1987). These projects combined special resources with staff who wished to work closely with farmers, and who had the freedom to do so.

For their part, international and national NGOs have advantages. It is true that they are scattered, of variable quality and usually small. They have also, as a whole, tended to be weak on the technical side of agriculture and inexpert at making links with formal agricultural research. Change, though, is rapid. In the late 1980s, many have been shifting their priorities, staff recruitment and training towards agriculture. NGOs have a comparative advantage, especially when they can maintain the same good staff in the field in the same place for a number of years. Some, like World Neighbors, the Central Mennonites Committee, the Aga Khan Rural Support Programmes, Oxfam, and Save the Childen Fund, already have a track record in farmer-first innovation. NGOs like these find it easier than large bureaucracies to avoid the trap of TOT, to recruit and maintain sensitive staff in the field, to be close to farmers, to encourage their participation and to act in farmer-first roles.

Farmers' organizations are a form of national NGO of growing significance. They have an increasing capacity to make demands on NARSs and to influence and sometimes even fund research. They tend, though, to represent the better-endowed farmers and those who produce for standard large-scale markets. The resource-poor farmers of CDR agriculture tend to be unorganized and to have diverse needs which defy simple aggregation. For them, demand-pull will always be weaker and the responsibility for putting their priorities first rests much more with other NGOs and with individual professionals.

A plurality of organizations can combine to gain strength in diversity. This has been observed in Eastern Bolivia (Thiele et al, 1988), where area-based development projects, NGOs and producers' organizations have been 'intermediate users' of technology, exercising demands on the formal research organization on behalf of farmers. There and elsewhere, both organizational links and staff careers are becoming more varied and plural. Projects provide resources for scientists to travel and for fieldwork with farmers. NGOs arrange visits for farmers to other areas. NGOs overcome their lack of agricultural competence by recruiting staff who leave government service, or, as in the Sudan, by paying them supplements while they remain on the government payroll.

A pluralist strategy, involving a variety of large and small organizations, partly answers questions of cost-effectiveness in the use of scientists' time. Sometimes the opportunity costs of scientists working on CDR agriculture may appear high, for instance if an African country has only a few scientists to work on an industrial crop of national importance. Further, there are usually far fewer scientists per farming system in CDR than in Green Revolution agriculture. A case could be put that scientists' impact working on CDR agriculture will be low. This has been evident so far. Concern is expressed that so much of the output of research is not adopted by farmers, with the rate of rejection in India informally estimated at 80 per cent or more, with probably a higher figure for rainfed agriculture.

The farmer-first mode promises greater cost-effectiveness. Where NGOs or extension agents are the convenors, catalysts and communicators, scientists can be used sparingly as consultants. When farmers play a full part, they themselves take account of local diversity in a manner that makes low demands on scarce scientific staff. When scientists spend more time searching for genetic material, technologies and principles for farmers to try, adapt and choose between, they may have more impact. Above all, putting farmers' agendas first and helping them to meet their priorities should be a sure path to good use of time. In a plural farmer-first approach, farmers, NGO workers, extensionists and agricultural researchers can specialize and support each other, with farmers and their groups and networks doing most, and the others serving them. In making the most of scarce staff, pluralism should pay off.

Practical Action: Starting and Sustaining Change

Professionals concerned with agricultural innovation, research and extension – whether they are farmers, or physical, biological or social scientists, and whether they are independent or working in universities, training institutes, government departments or NGOs – will have found in this book many ideas for what they might do. Non-farming agricultural professionals, just like resource-poor farmers, are faced with diversity and complexity, and similarly need a repertoire of methods so that they can be versatile and adaptable.

At a personal level, it is tempting to say that nothing can be done until a whole bureaucratic and professional system changes. Usually, though, there is room for manoeuvre. Some steps can be taken; a start can almost always be made. Even if the start is small and progress slow, it may be the seed of a self-sustaining movement. In the spirit of the learning process approach to development, it is better to start, to do something and to learn on the way, than to wait for better conditions before acting.

In the spirit of pluralism, action can and should start in many places. But not everything can be done at once. There are questions of how and where to start.

Two principles help here. The first is to start where it is easier, simpler and quicker, while weighing the danger of biases against poorer farmers. It is better to start and learn by doing and through mistakes than to wait for perfect conditions. By starting, experience is gained and confidence built up.

The second principle is to change behaviour before attitudes. Preaching about attitudes invites acquiescence without deep change. Action means experience gained and that, more than exhortation, reorients attitudes and habits of thought.

Taking these two principles together, analysis by and with farmers appears the most promising point of entry, followed by search, choice and experiment. A basic question to ask is what farmers would like in their basket of choices. From this question follow demands which reverse the normal top-down flow. Whether a department of agriculture, a university, an NGO or combinations of these can handle such requests can then be put to the test. Activities and roles then have to change. Procedures to accept and handle demands are required. Information systems for management from below have to be created and made to work. Subsequently, other elements of the paradigm become active, with testing and experiments by farmers and consultative support by others.

It is one thing to start and establish a bridgehead. It is quite another to sustain and spread it. The experiences reported by the International Service for National Agricultural Research's (ISNAR) On-Farm Client-Oriented Research project in nine national institutes are sobering. They include difficulty maintaining an interdisciplinary focus, vulnerability to the withdrawal of special support, a tendency to methodological stagnation, a loss of early enthusiasm and of farmer participation, and a career ladder which leads away from collaboration on-farm and towards specialization on-station (Merrill-Sands, 1988; von der Osten et al, 1988). With farmer-first, similar problems can be expected but also differences. The approach and methods described by the contributors to this book go further than most on-farm research, exploiting as they do the comparative advantage of farmers' knowledge, continuity and capacity for innovation. When it is farmers, with their full experience of their own farming systems, who analyse, experiment, monitor and make judgments, it is less important to sustain an interdisciplinary focus; farmers' enthusiasm and participation are more likely; and if outside support weakens, farmers can carry on on their own, and make their own demands on the research system, strengthened by their personal interest and participation. Compared with on-farm research in the TOT mode, the farmer-first mode promises to be feasible with a lighter touch and sustainable with less outside support.

Finally, for professionals to innovate by working in the farmer-first mode demands vision and leadership on the part of those with power and responsibility. These include senior officials in capital cities, vice-chancellors and deans, directors of research stations, leaders of teams and senior staff in regional, provincial and district headquarters, as well as in aid agencies and NGOs. Leaders can act like normal professionals and normal bureaucrats who simplify, standardize and stifle; or they can break out and encourage and support initiative and change, providing resources and room for manoeuvre for those under their management who have the aptitude and will to work in new participatory ways; and they can reorganize departments, procedures and management information systems so that searches can be made to meet farmers' demands and fill their basket with choices.

Alliances and mutual support also help. Those who see or sense the potential will do well to seek out and support like-minded fellow professionals in their own and other organizations. Shared ideas and experiences speed up learning. If those in this book provide stimulus and encouragement, they will have served their purpose. And if the new paradigm fulfils its promise, and is accepted and practiced much more in the 1990s and the 21st century, then those who take risks now to support, develop and spread it will not have acted in vain.

For the stakes are high. Over a billion people are supported by the third agriculture. The challenge is to enable many of the poorer among them to secure better and more sustainable livelihoods from their complex, diverse and risk-prone farming when normal agricultural research has so largely failed. This book points to new potentials. It shows that reversals in the farmer-first mode can be effective for farmers and exciting for professionals. A quiet revolution has already started, but it is scattered and still small scale. Which countries, institutions and individuals will now lead remains to be seen. Change depends on personal decisions and action. Those who now explore the frontiers of farmer participation cannot expect Nobel prizes, or be confident of early recognition or promotion; but they will be joining a vanguard. Their rewards, more surely, will be the exhilaration of pioneering, the satisfaction of seeing innovations spread and the knowledge that through their work, poor farm families are being truly served.

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7

Participatory Learning for Sustainable Agriculture

Jules Pretty

Recent Impacts of Sustainable Agriculture

During the past 50 years, agricultural development policies and practices have successfully emphasized external inputs as the means to increase food production. This has led to growth in global consumption of pesticides, inorganic fertilizer, animal feedstuffs, and tractors and other machinery.

These external inputs have, however, tended to substitute for natural processes and resources, rendering them more vulnerable. Pesticides have replaced biological, cultural and mechanical methods for controlling pests, weeds and diseases; inorganic fertilizers have substituted for livestock manures, composts and nitrogen-fixing crops; information for management decisions comes from input suppliers, researchers and extensionists rather than from local sources; machines have replaced labour; and fossil fuels have substituted for local energy sources. The basic technical challenge for those concerned with sustainable agriculture is to make better use of these internal resources. This can be done by minimizing the external inputs used, by regenerating internal resources more effectively, or by combinations of both.

There is now emerging evidence that regenerative and resource-conserving technologies and practices can bring both environmental and economic benefits for farmers, communities and nations. The best evidence comes from countries of Africa, Asia and Latin America, where the concern is to increase food production in the areas where farming has been largely untouched by the modern packages of externally supplied technologies. In these complex and remote lands, some farming communities adopting regenerative technologies have substantially improved agricultural yields, often only using few or no external inputs (Bunch, 1991, 1993; GTZ, 1992; UNDP, 1992; Lobo and Kochendörfer-Lucius, 1992; Krishna, 1993; Shah, 1994; SWCB, 1994; Balbarino and Alcober, 1994; Pretty, 1995).

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But these are not the only sites for successful sustainable agriculture. In the high-input and generally irrigated lands, farmers adopting regenerative technologies have maintained yields whilst substantially reducing their use of inputs (Bagadion and Korten, 1991; Kenmore, 1991; van der Werf and de Jager, 1992; UNDP, 1992; Kamp et al, 1993; Pretty, 1995). And in the very high input lands of the industrialized countries, farmers have been able to maintain profitability, even though input use has been cut dramatically, such as in the USA (Liebhart et al, 1989; NRC, 1989; Hanson et al, 1990; Faeth, 1993; NAF, 1994); and in Europe (El Titi and Landes, 1990; Vereijken, 1990; Jordan et al, 1993; Pretty and Howes, 1993; Reus et al, 1994).

All of these successes have elements in common. Farmers have made use of resource-conserving technologies, such as Integrated Pest Management, soil and water conservation, integrated plant nutrition and recycling, multiple cropping, water harvesting and waste recycling. There has been action by groups and communities at local level, with farmers becoming experts at managing farms as ecosystems, and at collectively managing the watersheds or other resource units of which their farms form part. And there have been supportive and enabling external government and/or non-government institutions, often working in new partnerships with new participatory methodologies, which have reoriented their activities to focus on local needs and capabilities.

Sustainability as a Contested Term

Although it is relatively easy to describe goals for a more sustainable agriculture, things become much more problematic when it comes to attempts to define sustainability: 'everyone assumes that agriculture must be sustainable. But we differ in the interpretations of conditions and assumptions under which this can be made to occur' (Francis and Hildebrand, 1989, p8).

A great deal of effort has gone into trying to define sustainability in absolute terms. Since the Brundtland Commission's definition of sustainable development (WCED, 1987), there have been at least 70 more definitions constructed, each different in subtle ways, each emphasizing different values, priorities and goals. The implicit assumption in many is that it is possible to come up with a single correct definition. Each author presumably regards his or her effort as the best.

But precise and absolute definitions of sustainability, and therefore of sustainable agriculture, are impossible. Sustainability itself is a complex and contested concept. To some it implies persistence and the capacity of something to continue for a long time. To others, it implies resilience, and the ability to bounce back after unexpected difficulties. With regard to the environment, it is used to imply not damaging or degrading natural resources. Others see it as a concept that means developmental activities that simply take account of the environment. Economies are sometimes said to be sustainable if economic activities do not harm the natural resource base; to others, sustainability simply implies continuing to grow at the same rate.

In any discussions of sustainability, it is important to clarify what is being sustained, for how long, for whose benefit and at whose cost, over what area and measured by what criteria. Answering these questions is difficult, as it means assessing and trading off values and beliefs (Campbell, 1994a). It also means that we can never be certain about sustainability. The 'undecidability theorem', proved by the logician Alan Turing in the 1930s, captures this essence: the theorem says that no matter how clever we think we are, there will always be algorithms (sets of rules) that do things we cannot predict in advance. The only way to find out what will happen is to run them (in Waldrop, 1992, p234).

Nonetheless, when specific parameters or criteria are selected, it is possible to say whether certain trends are steady, going up or going down. At the farm or community level, it is possible for actors to weigh up, trade off and agree on these criteria for measuring trends in sustainability. But as we move to higher levels of the hierarchy, to districts, regions and countries, it becomes increasingly difficult to do this in any meaningful way.

It is critical, therefore, that sustainable agriculture does not prescribe a concretely defined set of technologies, practices or policies. This would only serve to restrict the future options of farmers. Although many resource-conserving technologies and practices have been widely proven on research stations to be both productive and environmentally sensitive, the total number of farmers using them is still small. Part of the problem is that scientists experience quite different conditions to those experienced by farmers, and few farmers are able to adopt the whole packages of technologies without considerable adjustments. Despite the benefits of resource-conserving technologies, if they are imposed on farmers, then they will not be adopted widely.

One example is alley cropping, an agroforestry system comprising rows of nitrogen-fixing trees or bushes separated by rows of cereals, which has long been the focus of research (Kang et al, 1984; Attah-Krah and Francis, 1987; Lal, 1989). Many productive and sustainable systems, needing few or no external inputs, have been developed. They stop erosion, produce food and wood and can be cropped over long periods. But the problem is that very few, if any, farmers have adopted these alley cropping systems as designed. Despite millions of dollars of research expenditure over many years, systems have been produced suitable only for research stations. Where there has been some success, however, is where farmers have been able to take one or two components of alley cropping, and then adapt them to their own farms. In Kenya, for example, farmers planted rows of leguminous trees next to field boundaries, or single rows through their fields; and in Rwanda, alleys planted by extension workers soon became dispersed through fields (Kerkhof, 1990).

But the prevailing view tends to be that it is farmers who should adapt to the technology. Of the Agroforestry Outreach Project in Haiti, it was said that 'Farmer management of hedgerows does not conform to the extension program... Some farmers prune the hedgerows too early, others too late. Some hedges are not yet pruned by two years of age, when they have already reached heights of 4–5 metres. Other hedges are pruned too early, mainly because animals are let in or the tops are cut and carried to animals... Finally, it is very common for farmers to allow some of the trees in the hedgerow to grow to pole size' (Bannister and Nair, 1991, pp54–55).

This contrasts starkly with a recent analysis of sustainable agriculture initiatives in Guatemala and Honduras. A learning group from the non-governmental organization (NGO), COSECHA, returned to areas where projects had ended 3, 4 and 15 years previously, and used participatory methods with local communities to investigate changes (Bunch and López, 1994). They found that those communities in the project areas were substantially better off economically and socially. But, surprisingly, many of the technologies known to be 'successful' during the project (those that had increased crop yields without damaging the environment) had been completely replaced by new practices and, in all, some 80–90 innovations were documented. This has led Bunch and López (personal communication, 1994) to conclude that 'technologies are not sustainable: what needs to be made sustainable is the process of innovation itself'.

As conditions and knowledges change, so must farmers and communities be encouraged and allowed to change and adapt too. Again, this implies that any definitions of sustainability are time- and place-specific. As situations and conditions change, so must our constructions of sustainability also change. Sustainable agriculture is, therefore, not simply an imposed model or package. It must become a process for learning and perpetual novelty.

Science and Sustainability

Although there exist successful applications of sustainable agriculture throughout the world, still relatively few farmers have adopted new technologies and practices. One reason is that sustainable agriculture presents a deeper and more fundamental challenge than many researchers, extensionists and policy makers have yet supposed. Sustainable agriculture needs more than new technologies and practices. It needs agricultural professionals willing and able to learn from farmers and other stakeholders; it needs supportive external institutions; it needs local groups and institutions capable of managing resources effectively; and above all it needs agricultural policies that support these features. It also requires we look closely at the very nature of the way we conceptualize sustainability and how it might be achieved (Pretty, 1994, 1995).

Since the early 17th century, scientific investigation has come to be dominated by the Cartesian paradigm, commonly called positivism or rationalism. This posits that there exists an objective external reality driven by immutable laws. Science seeks to discover the true nature of this reality, the ultimate aim being to discover, predict and control natural phenomena. Investigators proceed in the belief that they are detached from the world. The process of reductionism involves breaking down components of a complex world into discrete parts, analysing them, and then making predictions about the world based on interpretations of these parts. Knowledge about the world is then summarized in the form of universal, or time- and context-free, generalizations or laws.

This methodology of science has been hugely successful, producing technologies and medicines that have enabled many people to live safer and more comfortable lives than ever before (Funtowicz and Ravetz, 1993). It is an approach that clearly works, and as a consequence, investigation with a high degree of control over the system being studied and where system uncertainties are low has become equated with good science. And such science is readily equated with 'true' knowledge, and so the 'only proper way' of thinking and doing.

But it is also this positivist approach that has led to the generation of farming technologies that have been applied widely and irrespective of local context. Where it has been possible to influence and control farmers, either directly or through economic incentives or markets, agricultural systems have been transformed. But where neither the technologies have fitted local systems nor have farmers been controlled, then agricultural modernization centred on positivist science has passed rural people by.

What the positivist paradigm does not recognize is that all data are constructed within a particular social and professional context. This context affects the outcomes, and can have a profound impact on policy and practice in agricultural development.

Michael Stocking (1993) has described just how the values of the investigators affect the end result when it comes to soil erosion data. Since the 1930s, there have been at least 22 erosion studies conducted in the Upper Mahaweli Catchment in Sri Lanka. These have used visual assessments of soil pedestals and root exposure, erosion pins, sediment traps, run-off plots, river and reservoir sediment sampling, and predictive models. Between the highest and lowest estimates of erosion under mid-country tea, there is an extraordinary variation of some 8000-fold, from 0.13 t/ha/yr to 1026 t/ha/yr (El-Swaify et al, 1983; NEDCO, 1984; Krishnarajah, 1985). The highest estimate was in the context of a development agency seeking to show just how serious erosion is in the developing world; the lowest was by a tea research institute seeking to show how safe was their land management. There was, however, nothing wrong with the scientific method; it was more a question of what the researchers defined as a problem, and how they chose to investigate it.

A similar case is described by Jerome Delli Priscoli (1989) regarding water and energy in the north-west of the USA. One projection for energy needs showed a steady growth to the year 2000; this was conducted by the utility company. Another showed a steadily downward trend; this was conducted by environmental groups. Other projections by consultancy groups were found towards the centre. What does this say about the data? 'Each projection was done in a statistically "pedigreed" fashion. Each was logical and internally elegant, if not flawless. The point is, once you know the group, you will know the relative position of their projection. The group, organization or institution embodies a set of values. The values are visions of the way the world ought to be' (Delli Priscoli, 1989, p36).

Both cases illustrate that science is not the neat, objective collection of facts about nature and its processes. The data were clearly constructed by people with values and human foibles. As Stocking (1993, p12) put it: 'What, then, is the right policy response? … Not surprisingly policy makers pick the measurements to suit their needs.' The challenge is not just that these differences have to be recognized, but that the competing values need to be mediated so as to produce agreements between actors with very different agendas. This calls for better forms of active participation and new platforms for decision making that engage wider public interests and social movements (Woodhill, 1993; Röling, 1994).

Alternatives and Additions to the Positivist Paradigm

One problem with the positivist paradigm is that its absolutist position appears to exclude other methodologies. Yet the important point about positivism is that it is just one of many ways of describing and analysing the world, and what is needed are pluralistic ways of thinking about the world and acting to change it (Kuhn, 1970; Feyerabend, 1975; Vickers, 1981; Checkland, 1981; Reason and Heron, 1986; Habermas, 1987; Giddens, 1987; Maturana and Varela, 1987; Rorty, 1989; Bawden, 1991; Uphoff, 1992; Wynne, 1992; Chambers, 1993; Funtowicz and Ravetz, 1993; Röling, 1994). Recent years have seen the emergence of a remarkable number of advances in a wide range of disciplines and fields of investigation. The sources include the so-called 'harder' sciences, such as physics, biology, chemistry, meteorology and mathematics, as well as the 'softer' sciences of philosophy, economics, sociology, architecture and organizational management.[1]

Despite this wide ranging list, those arguing for the seriousness and importance of developing additions to positivism are still in the minority. Many scientists continue to argue strongly that information is first produced by science, and only then interpreted and applied by the public and policy makers. It is this process of interpretation that is said to introduce values and confuse certainties. Yet the results from any investigation are always going to be open to different interpretations. All actors and stakeholders, and particularly those with a direct social or economic involvement and interest, have different perspectives on what constitutes a problem and/or improvement in an agricultural system.

These advances in alternative paradigms have important implications for how we go about finding out about the world, generating information and so taking action. All hold that 'the 'truth' is ultimately a kind of mirage that in principle cannot be achieved because the worlds we know are those crafted by us' (Eisner, 1990, p89). All suggest that we need to reform the way we think about methodologies for finding out about the world. Although these alternatives are emerging from a wide range of disciplines, there are five principles that differentiate them from positivist science (Pretty, 1994).

The first is that any attempt precisely to define concepts like sustainability is fundamentally flawed. It is a contested concept, and so represents neither a fixed set of practices or technologies, nor a model to describe or impose on the world. The question of defining what we are trying to achieve is part of the problem, as each individual has different values. Sustainable agriculture is, therefore, not so much a specific farming strategy as it is an approach to learning about the world.

The second is that problems are always open to interpretation. All actors have uniquely different perspectives on what is a problem and what constitutes improvement. As knowledge and understanding are socially constructed, what each of us knows and believes is a function of our own unique contexts and pasts. There is, therefore, no single 'correct' understanding. What we take to be true depends on the framework of knowledge and assumptions we bring with us. Thus it is essential to seek multiple perspectives on a problem situation by ensuring the wide involvement of different actors and groups.

The third is that the resolution of one problem inevitably leads to another 'problem-situation', as problems are endemic. The reflex of positivist science is to seek to collect sufficient data before declaring certainty about an issue or problem. As this position is believed to reflect the 'real world', then courses of action can become fixed and actors no longer seek information that might give another interpretation. Yet in a complex and changing world, there will always be uncertainties and new interpretations.

The fourth is that the key feature now becomes the capacity of actors (professionals, farmers and the public) continually to learn about these changing conditions, so that they can act quickly to transform existing activities. All should make uncertainties explicit and encourage rather than obstruct wider public debates about pursuing new paths for agricultural development. The world is open to multiple interpretations, and so it is impossible to say which one is true. Different constructed realities can only be related one to another.

The fifth is that systems of learning and action are needed to seek the multiple perspectives of the various interested parties and encourage their greater involvement. The view that there is only one epistemology (that is, the scientific one) has to be rejected. Participation is an essential component of any system of learning, as any change cannot be effected without the full involvement of all stakeholders and the adequate representation of their views and perspectives. As Sriskandarajah et al (1991, p4) put it: 'ways of researching need to be developed that combine "finding out" about complex and dynamic situations with "taking action" to improve them, in such a way that the actors and beneficiaries of the "action research" are intimately involved as participants in the whole process'.

All of this indicates that it is clearly time to break the domination of the old paradigm of positivism for science, and so explore the alternatives. This is not to suggest that there is no place for reductionist and controlled science. This will continue to have an important role to play where system uncertainties are low and problems are well defined and agreed. But it will no longer be seen as the sole type of inquiry. The process will inevitably mean huge transformations. Thomas Kuhn's

(1970) hugely influential analysis of paradigm changes in science describes the process of revolution for case after case. But the process can bring big shifts in understanding: 'During revolutions scientists see new and different things when looking with familiar instruments in places they have looked before' (Kuhn, 1970, p111).

The fundamental challenge facing agricultural scientists and development professionals is to find effective ways of involving a wider peer community (Funtowicz and Ravetz, 1993) and a greater breadth of social and cultural institutions (Woodhill, 1993) in the business of developing a more sustainable agriculture. Fortunately, they do not need to start just with theoretical analyses to shift underlying values. From practice, there has emerged a rich experience of the use of participatory methods for just this purpose.

The Many Interpretations of Participation

There is a long history of participation in agricultural development, and a wide range of development agencies, both national and international, have attempted to involve people in some aspect of planning and implementation. Two overlapping schools of thought and practice have evolved. One views participation as a means to increase efficiency, the central notion being that if people are involved, then they are more likely to agree with and support the new development or service. The other sees participation as a fundamental right, in which the main aim is to initiate mobilization for collective action, empowerment and institution building.

In recent years, there have been an increasing number of comparative studies of development projects showing that 'participation' is one of the critical components of success. It has been associated with increased mobilization of stakeholder ownership of policies and projects; greater efficiency, understanding and social cohesion; more cost-effective services; greater transparency and accountability; increased empowering of the poor and disadvantaged; and strengthened capacity of people to learn and act (Montgomery, 1983; Paul, 1987; USAID, 1987; Baker et al, 1988; Reij, 1988; Finsterbusch and van Wicklen, 1989; Bagadion and Korten, 1991; Cernea, 1991; Guijt, 1991; Kottak, 1991; Pretty and Sandbrook, 1991; Uphoff, 1992; Narayan, 1993; World Bank, 1994).

As a result, the terms 'people's participation' and 'popular participation' are now part of the normal language of many development agencies, including NGOs, government departments and banks (Adnan et al, 1992; Bhatnagar and Williams, 1992; World Bank, 1994). It is such a fashion that almost everyone says that participation is part of their work. This has created many paradoxes. The term 'participation' has been used to justify the extension of control of the state as well as to build local capacity and self-reliance; it has been used to justify external decisions as well as to devolve power and decision making away from external agencies; it has been used for data collection as well as for interactive analysis. But 'more often than not, people are asked or dragged into partaking in operations of no interest to them, in the very name of participation' (Rahnema, 1992, p116).

One of the objectives of agricultural support institutions must, therefore, be greater involvement with and empowerment of diverse groups of people, as sustainable agriculture is threatened without it. The dilemma for many authorities is they both need and fear people's participation. They need people's agreements and support, but they fear that this wider involvement is less controllable, less precise and so likely to slow down planning processes. But if this fear permits only stage-managed forms of participation, then distrust and greater alienation are the most likely outcomes. This makes it all the more crucial that judgements can be made on the type of participation in use.

In conventional rural development, participation has commonly centred on encouraging local people to sell their labour in return for food, cash or materials. Yet these material incentives distort perceptions, create dependencies, and give the misleading impression that local people are supportive of externally driven initiatives. This paternalism undermines sustainability goals and produces impacts which rarely persist once the project ceases (Bunch, 1983; Reij, 1988; Pretty and Shah, 1994; Kerr, 1994). Despite this, development programmes continue to justify subsidies and incentives, on the grounds that they are faster, that they can win over more people, or they provide a mechanism for disbursing food to poor people. As little effort is made to build local skills, interests and capacity, local people have no stake in maintaining structures or practices once the flow of incentives stops.

The many ways that development organizations interpret and use the term participation can be resolved into seven clear types. These range from manipulative and passive participation, where people are told what is to happen and act out predetermined roles, to self-mobilization, where people take initiatives largely independent of external institutions (Table 7.1). This typology suggests that the term 'participation' should not be accepted without appropriate clarification. The World Bank's internal 'Learning Group on Participatory Development', in seeking to clarify the benefits and costs of participation, distinguished between different types of participation: 'many Bank activities which are termed "participatory" do not conform to [our] definition, because they provide stakeholders with little or no influence, such as when [they] are involved simply as passive recipients, informants or labourers in a development effort' (World Bank, 1994, p6). The problem with participation as used in types one to four is that any achievements are likely to have no positive lasting effect on people's lives (Rahnema, 1992). The term participation can be used, knowing it will not lead to action. Indeed, some suggest that the manipulation that is often central to types one to four mean they should be seen as types of non-participation (Hart, 1992).

A recent study of 230 rural development institutions employing some 30,000 staff in 41 countries of Africa found that participation for local people was most likely to mean simply having discussions or providing information to external

Table 7.1 *A typology of participation: How people participate in development programmes and projects*

Typology	*Characteristics of each type*
1 *Manipulative participation*	Participation is simply a pretence, with 'people's' representatives on official boards but who are unelected and have no power
2 *Passive participation*	People participate by being told what has been decided or has already happened. It involves unilateral announcements by an administration or project management without any listening to people's responses. The information being shared belongs only to external professionals
3 *Participation by consultation*	People participate by being consulted or by answering questions. External agents define problems and information gathering processes, and so control analysis. Such a consultative process does not concede any share in decision making, and professionals are under no obligation to take on board people's views
4 *Participation for material incentives*	People participate by contributing resources, for example labour, in return for food, cash or other material incentives. Farmers may provide the fields and labour, but are involved in neither experimentation nor the process of learning. It is very common to see this called participation, yet people have no stake in prolonging technologies or practices when the incentives end
5 *Functional participation*	Participation seen by external agencies as a means to achieve project goals, especially reduced costs. People may participate by forming groups to meet predetermined objectives related to the project. Such involvement may be interactive and involve shared decision making, but tends to arise only after major decisions have already been made by external agents. At worst, local people may still only be co-opted to serve external goals
6 *Interactive participation*	People participate in joint analysis, development of action plans and formation or strengthening of local institutions. Participation is seen as a right, not just the means to achieve project goals. The process involves interdisciplinary methodologies that seek multiple perspectives and make use of systemic and structured learning processes. As groups take control over local decisions and determine how available resources are used, so they have a stake in maintaining structures or practices
7 *Self-mobilization*	People participate by taking initiatives independently of external institutions to change systems. They develop contacts with external institutions for resources and technical advice they need, but retain control over how resources are used. Self-mobilization can spread if governments and NGOs provide an enabling framework of support. Such self-initiated mobilization may or may not challenge existing distributions of wealth and power

Source: Adapted from Pretty (1994), Satterthwaite et al (1995), Adnan et al (1992), Hart (1992) agencies (Guijt, 1991). Government and non-government agencies rarely permitted local groups to work alone, some even acting without any local involvement. These external agencies did permit some joint decisions, but usually controlled all the funding.

Another study of 121 rural water supply projects in 49 countries of Africa, Asia and Latin America found that participation was the most significant factor contributing to project effectiveness and maintenance of water systems (Narayan, 1993). Most of the projects referred to community participation or made it a specific project component, but only 21 per cent scored high on interactive participation. Clearly, intentions did not translate into practice. It was when people were involved in decision making during all stages of the project, from design to maintenance, that the best results occurred. If they were just involved in information sharing and consultations, then results were much poorer. According to the analysis, it was quite clear that moving down the typology moved a project from a medium to highly effective category.

Great care must, therefore, be taken over both using and interpreting the term participation. It should always be qualified by reference to the type of participation, as most types will threaten rather than support the goals of sustainable agriculture. What will be important is for institutions and individuals to define better ways of shifting from the more common passive, consultative and incentive-driven participation towards the interactive end of the spectrum.

Alternative Systems of Learning and Action

Recent years have seen a rapid expansion in new participatory methods and approaches to learning in the context of agricultural development (see *PLA Notes (formerly RRA Notes)*, 1988-present; SPRA, 1982[2]; Rahman, 1984; Conway, 1987; Grandin, 1987; KKU, 1987; Scrimshaw and Hurtado, 1987; Rocheleau et al, 1989; NES/CU/EU/WRI, 1990; Rhoades, 1990; Campbell and Gill, 1991; Mascarenhas et al, 1991; Chambers, 1994a, 1994b, 1994c; IDS/IIED, 1994; Pretty et al, 1995). Many have been drawn from a wide range of non-agricultural contexts, and were adapted to new needs. Others are innovations arising out of situations where practitioners have applied the methods in a new setting, the context and people themselves giving rise to the novelty.

There are now more than 30 different terms for these systems of learning and action, some more widely used than others.[3] Participatory Rural Appraisal (PRA), for example is now practised in at least 130 countries, but Samuhik Brahman is associated just with research institutions in Nepal, and REFLECT just with adult literacy programmes. But this diversity and complexity is a strength. It is a sign of both innovation and ownership. Despite the different contexts in which these approaches are used, there are important common principles uniting most of them. These systems emphasize the following six elements:

1 *A Defined Methodology and Systemic Learning Process* – the focus is on cumulative learning by all the participants and, given the nature of these approaches as systems of inquiry and interaction, their use has to be participative. The emphasis on visualizations democratizes and deepens analysis.
2 *Multiple Perspectives* – a central objective is to seek diversity, rather than characterize complexity in terms of average values. The assumption is that different individuals and groups make different evaluations of situations, which lead to different actions. All views of activity or purpose are heavy with interpretation, bias and prejudice, and this implies that there are multiple possible descriptions of any real-world activity.
3 *Group Learning Process* – all involve the recognition that the complexity of the world will only be revealed through group inquiry and interaction. This implies three possible mixes of investigators, namely those from different disciplines, from different sectors, and from outsiders (professionals) and insiders (local people).
4 *Context Specific* – the approaches are flexible enough to be adapted to suit each new set of conditions and actors, and so there are multiple variants.
5 *Facilitating Experts and Stakeholders* – the methodology is concerned with the transformation of existing activities to try to bring about changes which people in the situation regard as improvements. The role of the 'expert' is best thought of as helping people in their situation carry out their own study and so achieve something.
6 *Leading to Sustained Action* – the learning process leads to debate about change, and debate changes the perceptions of the actors and their readiness to contemplate action. Action is agreed, and implementable changes will therefore represent an accommodation between the different conflicting views. The debate and/or analysis both defines changes which would bring about improvement and seeks to motivate people to take action to implement the defined changes. This action includes local institution building or strengthening, so increasing the capacity of people to initiate action on their own.

The participatory methods (sometimes called tools, techniques or instruments[4]) used in these systems of learning and action can be structured into four classes: methods for group and team dynamics, for sampling, for interviewing and dialogue, and for visualization and diagramming (Table 7.2). It is the collection of these methods into unique approaches, or assemblages of methods, that constitute different systems of learning and action.

Participation calls for collective analysis. Even a sole researcher must work closely with local people (often called 'beneficiaries', 'subjects', 'respondents' or 'informants'). Ideally, though, teams of investigators work together in interdisciplinary and intersectoral teams. By working as a group, the investigators can approach a situation from different perspectives, carefully monitor one another's work, and carry out a variety of tasks simultaneously. Groups can be powerful when they function well, as performance and output is likely to be greater than the sum of its

Table 7.2 *Participatory methods for alternative systems of learning and action*

Group and team dynamics methods	*Sampling methods*	*Interviewing and dialogue*	*Visualization and diagramming methods*
• Team contracts • Team reviews and discussions • Interview guides and checklists • Rapid report writing • Energisers • Work sharing (taking part in local activities) • Villager and shared presentations • Process notes and personal diaries	• Transect walks • Wealth ranking and well-being ranking • Social maps • Interview maps	• Semi-structured interviewing • Direct observation • Focus groups • Key informants • Ethnohistories and biographies • Oral histories • Local stories, portraits and case studies	• Mapping and modelling • Social maps and wealth rankings • Transects • Mobility maps • Seasonal calendars • Daily routines and activity profiles • Historical profiles • Trend analyses and time lines • Matrix scoring • Preference or pairwise ranking • Venn diagrams • Network diagrams • Systems diagrams • Flow diagrams • Pie diagrams

individual members. Many assume that simply putting together a group of people in the same place is enough to make an effective team. This is not the case. Shared perceptions, essential for group or community action, have to be negotiated and tested. Yet, the complexity of multidisciplinary team work is generally poorly understood. A range of workshop and field methods can be used to facilitate this process of group formation.

In order to ensure that multiple perspectives are both investigated and represented, practitioners must be clear about who is participating in the data-gathering, analysis and construction of these perspectives. Communities are not homogenous entities, and there is always the danger of assuming that those participating are representative of all views. There are always differences between women and men, between poor and wealthy, between young and old. Those missing, though, are usually the socially marginalized (see Rocheleau, 1991; Guijt and Kaul Shah, 1995). Rigorous sampling is, therefore, an essential part of these participatory approaches, and a range of field methods is available.

Sensitive interviewing and dialogue are a third element of these systems of participatory learning. For the reconstructions of reality to be revealed, the conventional dichotomy between the interviewer and respondent should not be permitted to develop. Interviewing is, therefore, structured around a series of methods that promote a sensitive dialogue. This should appear more like a structured conversation than an interview.

The fourth element is the emphasis on diagramming and visual construction. In formal surveys, information is taken by interviewers, who transform what people say into their own language. By contrast, diagramming can give local people a share in the creation and analysis of knowledge, providing a focus for dialogue which can be sequentially modified and extended. Local categories, criteria and symbols are used during diagramming, which include mapping and modelling, comparative analyses of seasonal, daily and historical trends, ranking and scoring methods to understand decision making, and diagrammatic representations of household and livelihood systems. Rather than answering questions which are directed by the values of the researcher, local people are encouraged to explore their own versions of their worlds. Visualizations, therefore, help to balance dialogue and increase the depth and intensity of discussion.

These alternative methodologies imply a process of learning leading to action. A more sustainable agriculture, with all its uncertainties and complexities, cannot be envisaged without a wide range of actors being involved in continuing processes of learning. Some of the changes underway are remarkable. In a growing number of government and non-government institutions, extractive research is being supplemented by investigation by local people themselves. Participatory methods are being used not just for local people to inform outsiders, but also for people's own analyses of their own conditions (Pretty and Chambers, 1993; Chambers, 1994a, 1994b, 1994c).

The contrast between systems of learning that involve a wider community than just scientists is illustrated by a recent example from the development of the Landcare movement in Australia (Woodhill, 1993; Campbell, 1994b). Jim Woodhill (1993, p1) put it this way: 'Scientists had been monitoring the problem [salinity] for along time and producing a range of publications to inform farmers. What was now significant was the way the farmers talked about the dramatic impact "doing their own science" had on their understanding, motivation to act, and willingness to engage in more fruitful ways with the "experts".'

The Trustworthiness of Findings

It is common for users who have presented findings arising from the use of participatory methods to be asked a question along the lines of 'but how does it compare with the real data?' (see Gill, 1991, p5). It is commonly asserted that participatory methods constitute inquiry that is undisciplined and sloppy. It is said to involve only subjective observations and so reflect just selected members of communities. Terms like informal and qualitative are used to imply poorer quality or second-rate work. Rigour and accuracy are assumed, therefore, to be in contradiction with participatory methods.

This means that it is the investigators relying on participatory methods who are called upon to prove the utility of their approach, not the conventional investigator. Conventional research uses four criteria in order to persuade their audiences that the findings of an inquiry can be trusted (see Lincoln and Guba, 1985; Guba and Lincoln, 1989). How can we be confident about the 'truth' of the findings (internal validity)? Can we apply these findings to other contexts or with other groups of people (external validity)? Would the findings be repeated if the inquiry were replicated with the same (or similar) subjects in the same or similar context (reliability)? How can we be certain that the findings have been determined by the subjects and context of the inquiry, rather than the biases, motivations and perspectives of the investigators (objectivity)? These four criteria, though, are dependent for their meaning on the core assumptions of the conventional research paradigm (Cook and Campbell, 1979; Lincoln and Guba, 1985; Kirk and Miller, 1986).

Trustworthiness criteria were first developed by Guba (1981) to judge whether or not any given inquiry was methodologically sound. Four alternative, but parallel, criteria were developed: credibility, transferability, dependability and conformability. But these '*had their foundation in concerns indigenous to the conventional, or positivist, paradigm*' (Lincoln, 1990, p71). To distinguish between elements of inquiry that were not derived from the conventional paradigm, further 'authenticity' criteria have been suggested to help in judging the impact of the process of inquiry on the people involved (Lincoln, 1990). Have people been changed by the process? Have they a heightened sense of their own constructed realities? Do they have an increased awareness and appreciation of the constructions of other stakeholders? To what extent did the investigation prompt action?

Drawing on these, and other suggestions for 'goodness' criteria (Marshall, 1990; Smith, 1990), a framework of 12 criteria for establishing trustworthiness have been identified (Pretty, 1994).

1. *Prolonged and/or Intense Engagement Between the Various Actors*
   For building trust and rapport, learning the particulars of the context, and keeping the investigator(s) open to multiple influences. Trust takes a long time to build, but can be destroyed overnight. It is increased by confirming that participants will have an input into, and so influence, the learning process.
2. *Persistent and Critical Observation*
   For understanding both a phenomenon and its context. Observation increases the depth of understanding and breadth of realities encountered.
3. *Parallel Investigations and Team Communications*
   If subgroups of the same team proceed with investigations in parallel using the same methodology, and come up with the same or similar findings, then

these findings are trustworthy. This requires regular formal meetings and agreed group norms of behaviour.

4 *Triangulation by Multiple Sources, Methods and Investigators*
For cross-checking information and increasing the range of peoples' realities encountered, including multiple copies of one type of source or different copies of the same information; comparing the results from a range of methods; and having teams with a diversity of personal, professional and disciplinary backgrounds.

5 *Analysis and Expression of Difference*
For ensuring that a wide range of different actors are involved in the analysis, and that their perspectives are accurately represented. These perspectives will not be resolved to a single consensus position.

6 *Negative Case Analysis*
For sequential revision of hypotheses as insight grows, so as to revise until one set of hypotheses accounts for all known cases.

7 *Participant Checking*
For testing the data, interpretations and conclusions with people with whom the original information was constructed and analysed. Participants have the opportunity to investigate discrepancies and challenge findings, to volunteer additional information, and to hear a summary of what investigators have learning and constructed. Without participant checks, investigators can make no claims that they are representing participants' views.

8 *Peer or Colleague Checking*
Periodical reviews with peers or colleagues not directly involved in the learning process, so as to expose investigators to searching questions.

9 *Reports with Working Hypotheses, Contextual Descriptions and Visualizations*
These are 'thick' descriptions of complex reality, with working hypotheses, visualizations and quotations capturing peoples' personal perspectives and experiences.

10 *Reflexive Journals*
These are diaries individuals keep on a daily basis to record a variety of information about themselves and sequential changes in methodology.

11 *Inquiry Audit*
The team should be able to provide sufficient information for a disinterested person to examine the processes and product in such a way as to confirm that the findings are not figments of their imaginations.

12 *Impact on Stakeholders' Capacity to Know and Act*
For demonstrating that the investigation has had an impact, including participants having a heightened sense of their own realities, as well as an increased appreciation of those of other people. The report could also prompt action on the part of readers who have not been directly involved.

These criteria can be used to judge quality, just as statistical analyses provide the grounds for judgement in positivist or conventional science. An application of an alternative system of learning without, for example, triangulation of sources, methods and investigators and participant checking of the constructed outputs, should be judged as untrustworthy. It will never be possible, however, to be certain about the trustworthiness criteria. Certainty is only possible if we fully accept the positivist paradigm. The criteria themselves are value-bound, and so we cannot say that 'x has a trustworthiness score of y points', but we can say that x is trustworthy because certain things happened during and after the investigation. The trustworthiness criteria should be used to identify what has been part of the process of generating information, and whether key elements have been omitted. Knowing this should make it possible for any observer, be they reader of a report or policy maker using the information to make a decision, also to make a judgement on whether they trust the findings. In this context, it becomes possible to state that the 'data no longer speak for themselves'.

Towards a New Professionalism

The elements of these systems of participatory learning, the values, principles, methods and trustworthiness criteria, will not be sufficient to provoke widespread change in institutions and individuals. The methods themselves are not neutral of historical, social and political context. They may be used to lead to genuine local capacity building and organisation, or they may be used to satisfy external objectives alone.

These systems of learning are centred on approaches that are alternatives to positivism. They are more likely to generate information already agreed and negotiated by various interest groups. As a result, the likelihood of conflicts is reduced. For these reasons, they can be good for decision makers, as the needs and values are explicit: 'inquiry that purports to be value-free is probably the most insidious form of inquiry available because its inherent but unexamined values influence policy without ever being scrutinized themselves' (Lincoln, 1990, p82, quoting Beardsley, 1980). However, there will never be any final, correct answers. There is no absolute trustworthiness, only trustworthiness for a given time in a given context. Furthermore, because all the actors can be said to trust a particular body of information at a particular time, this does not mean to say they will always do so. As external conditions change, so their values and criteria for judging will also change. The information may then come to be judged as untrustworthy, with various people no longer having confidence in it.

It will be important to ensure the construction and generation of timely, relevant, agreed information and knowledge that will support the quest towards a sustainable agriculture. This raises two challenges: finding ways of developing both new institutional arrangements and alliances to encourage greater learning and wider peer involvement; and a whole new professionalism with greater understanding of the range of scientific methodologies and an emphasis on the process of learning (and unlearning) itself.

The central concept of sustainable agriculture is that it must enshrine new ways of learning about the world. Such learning should not be confused with 'teaching'. Teaching implies the transfer of knowledge from someone who knows to someone who does not know, and is the normal mode of educational curricula (Ison, 1990; Argyris, 1991; Russell and Ison, 1991; Bawden, 1992, 1994; Pretty and Chambers, 1993). Universities and other professional institutions reinforce the teaching paradigm by giving the impression that they are custodians of knowledge which can be dispensed or given (usually by lecture) to a recipient (a student). Where teaching does not include a focus on self-development and enhancing the ability to learn, then 'teaching threatens sustainable agriculture' (Ison, 1990).

A move from a teaching to a learning style has profound implications for agricultural development institutions. The focus is less on *what* we learn, and more on *how* we learn and *with whom*. This implies new roles for development professionals, leading to a whole new professionalism with new concepts, values, methods and behaviour (Table 7.3). Typically, normal professionals are single-disciplinary, work largely in ways remote from people, are insensitive to diversity of context, and are concerned with themselves generating and transferring technologies. Their beliefs about people's conditions and priorities often differ from people's own views. The new professionals, by contrast, make explicit their underlying values, select methodologies to suit needs, are more multidisciplinary and work closely with other disciplines, and are not intimidated by the complexities and uncertainties of dialogue and action with a wide range of non-scientific people (Pretty and Chambers, 1993).

But it would be wrong to characterize this as a simple polarisation between old and new professionalism, implying in some way the bad and the good. True sensibility lies in the way opposites are synthesized. It is clearly time to add to the paradigm of positivism for science, and embrace the new alternatives. This will not be easy. Professionals will need to be able to select appropriate methodologies for particular tasks (Funtowicz and Ravetz, 1993). Where the problem situation is well defined, system uncertainties are low, and decision stakes are low, then positivist and reductionist science will work well. But where the problems are poorly defined and there are great uncertainties potentially involving many actors and interests, then the methodology will have to comprise these alternative methods of learning. Many existing agricultural professionals will resist such paradigmatic changes, as they will see this as a deprofessionalization of research. But Hart (1992, p19) has put it differently: 'I see it as a "re-professionalisation", with new roles for the researcher as a democratic participant.'

A systematic challenge for agricultural and rural institutions, whether government or non-government, is to institutionalize these approaches and structures that encourage learning. Most organizations have mechanisms for identifying departures from normal operating procedures. This is what Argyris (1991) calls single-loop learning. But most institutions are very resistant to double-loop learning, as this involves the questioning of, and possible changes in, the wider values and procedures under which they operate. For organizations to become learning

Table 7.3 *Towards a new professionalism for sustainable agriculture*

Elements	*Components of the new professionalism*
Assumptions about reality	The assumption is that realities are socially constructed, and so participatory methodologies are required to relate these many and varied perspectives one to another
Underlying values	Underlying values are not presupposed, but are made explicit; old dichotomies of facts and values, and knowledge and ignorance, are transcended
Scientific method(s)	The many scientific methods are accepted as complementary; with reductionist science for well-defined problems and when system uncertainties are low; and holistic and constructivist science when problem situations are complex and uncertain
Who sets priorities and whose criteria count?	A wide range of stakeholders and professionals set priorities together; local people's criteria and perceptions are emphasized
Context of researching process	Investigators accept that they do not know where research will lead; it has to be an open-ended learning process; historical and spatial context of inquiry is fundamentally important
Relationship between actors and groups in the process	Professionals shift from controlling to enabling mode; they attempt to build trust through joint analyses and negotiation; understanding arises through this interaction, resulting in deeper relationships between investigator(s), the 'objects' of research, and the wider communities of interest
Mode of professional working	More multidisciplinary than single disciplinary when problems difficult to define; so attention is needed on the interactions between members of groups working together
Institutional involvement	No longer just scientific or higher-level institutions involved; process inevitably comprises a broad range of societal and cultural institutions and movements at all levels
Quality assurance and evaluation	There are no simple, objective criteria for quality assurance: criteria for trustworthiness replace internal validity, external validity, objectivity and reliability when methods is non-reductionist; evaluation is no longer by professionals or scientists alone, but by a wide range of affected and interested parties (the extended peer community)

Source: Adapted from Pretty and Chambers (1993)

organizations, they must ensure that people become aware of the way they learn, both from mistakes and from successes.

Institutions can, therefore, improve learning by encouraging systems that develop a better awareness of information. The best way to do this is to be in close touch with external environments, and to have a genuine commitment to participative decision making, combined with participatory analysis of performance. Learning organizations will, therefore, have to be more decentralized, with an open multidisciplinarity, and heterogeneous outputs responding to the demands and needs of farmers. These multiple realities and complexities will have to be understood through multiple linkages and alliances, with regular participation between professional and public actors. It is only when some of these new professional norms and practices are in place that widespread changes in the livelihoods of farmers and their natural environments are likely to be achieved.

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Notes

1 Alternatives, additions and challenges to the positivist paradigm have emerged from a very wide range of disciplines, including from chaos theory and non-linear science (Prigogine and Stengers, 1984; Gleick, 1987; Gould, 1989); fractal geometry and mathematics (Family and Vicsek, 1991; Lorenz, 1993); quantum physics (see many sources, but especially theories of Schrödinger and Heisenberg); neural networks (Holland et al, 1986); soft-systems science (Checkland, 1981, 1989; Checkland and Scholes, 1990; Röling, 1994); post-normal science (Funtowicz and Ravetz, 1993); philosophy of symbiosis (Kurokawa, 1991); historical sociology (Abrams, 1989); morphic resonance (Sheldrake, 1988); popular epidemiology (Brown, 1987); complexity theory (Waldrop, 1992; Santa Fe Institute, *passim*); Gaia hypothesis (Lovelock, 1979); alternative economics (Arthur, 1989; Daly and Cobb, 1989; Ekins, 1990; Douthwaite, 1992); post-positivism (Phillips, 1990); critical systems theory (Popkewitz, 1990; Jackson, 1991; Tsoukas, 1992); constructivist inquiry (Denzin, 1984; Lincoln and Guba, 1985; Röling and Jiggins, 1994; Engel, 1995); communicative action (Habermas, 1987); postmodernism (Harvey, 1989); adaptive management and operationality in turbulence (Holling, 1978; Norgaard, 1989; Mearns, 1991; Roche, 1992; Uphoff, 1992); learning organizations and clumsy institutions (Argyris and Schön, 1978; Peters, 1987; Handy, 1989; Shapiro, 1988; Thompson and Trisoglio, 1993); and social ecology (Bawden, 1991, 1994; Woodhill, 1993).

2 This list of references cannot possibly be comprehensive, as the antecedents and actors involved are too numerous to mention. The informal journal *PLA Notes (formerly RRA Notes)* (in issues 1 to 22) has alone published 240 articles since 1988 based on field experiences in rural and urban communities in some 55 countries; and the IDS/IIED (1994) annotated bibliography contains a listing of some 600 references relating to Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA).

3 A selection of recently emerged terms of alternative systems of learning and action include Agroecosystems Analysis (AEA), Beneficiary Assessment, Development Education Leadership Teams

(DELTA), Diagnóstico Rurale Participativo (DRP), Farmer Participatory Research, Farming Systems Research, Groupe de Recherche et d'Appui pour l'Auto-Promotion Paysanne (GRAAP), Méthode Accélérée de Recherche Participative (MARP), Participatory Analysis and Learning Methods (PALM), Participatory Action Research (PAR), Participatory Research Methodology (PRM), Participatory Rural Appraisal (PRA), Participatory Rural Appraisal and Planning (PRAP), Participatory Technology Development (PTD), Participatory Urban Appraisal (PUA), Planning for Real, Process Documentation, Rapid Appraisal (RA), Rapid Assessment of Agricultural Knowledge Systems (RAAKS), Rapid Assessment Procedures (RAP), Rapid Assessment Techniques (RAT), Rapid Catchment Analysis (RCA), Rapid Ethnographic Assessment (REA), Rapid Food Security Assessment (RFSA), Rapid Multi-perspective Appraisal (RMA), Rapid Organisational Assessment (ROA), Rapid Rural Appraisal (RRA), Regenerated Freiréan Literacy through Empowering Community Techniques (REFLECT), Samuhik Brahman (Joint trek), Soft Systems Methodology (SSM), Theatre for Development, Training for Transformation, and Visualisation in Participatory Programmes (VIPP).

4 These terms, 'tool', 'technique' and 'instrument', imply a functionality that does not exist in practice. A tool, such as a screwdriver, guarantees an output from an input; a technique, such as how to join together two pieces of wood, is something that can be repeated by skilled practitioners; an instrument, such as a compass, unerringly measures and indicates. No participatory methods can guarantee outputs from given inputs as they involve the activities of diverse social actors, whose interests and concerns cannot be predicted in advance (see Checkland, 1989).

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8

Past, Present and Future

J. D. Van der Ploeg

We generally imagine society, and the practices and processes localized in it, as ordered by historically rooted patterns and relationships. Yet this idea, found in and promoted particularly by the social sciences, is increasingly open to challenge. Indeed, this idea becomes an obstacle to an adequate understanding of social processes and developments. However improbable it seems at first, contemporary society is increasingly ordered in a roundabout way – that is, via the future.

Human activity is always and everywhere future oriented. *Somos lo que vamos a ser*, we are what we are becoming, according to Ortega y Gasset (1995, p277).[1] This does not pre-empt the fact that the relations between past, present, and future are subject to radical changes. The way in which future-oriented actions are constituted and founded has changed drastically.

Within societies that are generally regarded as traditional, the future was understood, and subsequently created, as a repetition of the past. Previously acquired experiences plotted the course of the future. By pursuing that course in the present, the future became a repetition of past relations. The past was reproduced via the present through collective memory, through the fear of deviating from it, as well as through the convenience of the tried and true. Thus emerged a straight and above all narrow road, running from the past, via the present, to the future. A crucial role was played by what sociologists call *Gemeinschaft*. Well-defined norms applied to the levels of community, family, village and vocational group. One had to act according to norms reflecting what was well tried, what was historically just. Deviation resulted in sanctions.

A radical change was introduced into this initially monotonous scheme, during the period defined as the age of modernization.[2] The past turned from guiding principle to starting point, to be built upon in various ways; no longer according to the strict rules inherent to the *Gemeinschaft*, but according to new degrees of freedom applying to the *Gesellschaft*: people belonged to a class, to a society, they were part of markets, and they shared in the blessings of technical development.

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On the one hand, this new constellation introduced an often considerable set of limitations; on the other hand, it accommodated further unfolding and unfurling. Starting out from the foundations created in the past – and embodied in particular practices, resources, knowledges, and opportunities – various roads were developed towards a future that could be understood as a multifaceted process of unfolding the potentialities situated in what had been established so far (Kosik, 1976).

Thus, the present became an important link. It had been built on the past in specific and often contrasting ways. Hence, the future appeared as a vast array of possibilities – that is, those possibilities contained in the present to be utilized and realized subsequently.

At the moment, we already have one foot in an ensuing constellation,[3] which I will call, for the sake of convenience, the postmodern. In this constellation, the future is no longer the multifaceted utilization and unfolding of development opportunities situated in the present. Instead, the future becomes a beacon, strongly conditioning contemporary actions. If future-oriented actions were initially based in the routines of the past and later became founded on, and hence defined by, the opportunities located in the present – today, the construction of the future is systematically disconnected from both. History becomes almost irrelevant, and the present is reduced to merely a (more or less favourable) run-up to the future. The burning questions are who, or what, will in which way, construct the guiding images of the future.

All in all, the moment of ordering has shifted dramatically. Initially, this moment was hidden in history (for the future could not be anything but a repetition of the past). Collective memory, with its defined normative frame, constituted the moment of ordering par excellence. Later, in the age of modernization, the moment of ordering shifted to the present: even though the past was still built on, the way in which this happened was highly variable. The present became an essential, albeit highly variable, link between past and future. Taking the former achievements into consideration, one chose and realized multiple roads to the future. Thus the future became freed from its ties with the past.

If every moment represented a particular reality, it also contained various development opportunities, various routes to the future. Of course, of all those possibilities, only one could be realized in any given situation. Agency – that is, the capacity to achieve something – became decisive in this dance from reality to the future.

At present, the ordering moment is, to a large extent, located with those[4] who are able to specify where we are heading. However astonishing this may initially seem, images of the future almost irresistibly determine what we do today.

Social developments and practices are increasingly ruled and directed by such images of the future. In a way, the present becomes shackled by the limited and compelling images of the future that we create; for these images of the future define what is, in the here and now, sensible and rational and also what is absurd and irrational.

Remarkably, and in sharp contrast to the previous phase, these are no longer multiple and mutually contradistinctive images of the future (every one of which can potentially be realised) but instead they are compelling and exclusive. Only one option is regarded as feasible and legitimate. If a certain reality contained various alternatives in the past, now one single option acts as the selective frame in defining the preferred (or unavoidable) future reality. Institutionalized images of the future have become the pre-eminent moments of ordering. The expert systems that have emerged in recent decades are the most important carriers of this process.

Megaprojects (see Scott, 1998)[5] now constitute the largely contested, but still highly imperative frames that orient the actions of various actors towards one set of parameters: towards the future constellation that facilitates 'profits' and in which it is better to participate than to stand aside. Expert systems are crucial in constituting these megaprojects.

A similar development can be encountered in the markets. The most important markets no longer deal with commodities that are produced and traded here and now – they are concerned with the future. On option markets (and on stock markets) 'trade' is in expectations: trade is about the opportunity to supply and sell a certain commodity at a future price. The same applies to stock markets: they are inspired and constituted by expectations about future profits. Crucial in all this is that the actual trade taking place at present is dominated by the trade in expectations.

Figure 8.1 summarizes this argument. In traditional society (1a) past, present, and future were in alignment with each other. In modern society (1b) the present contains a series of alternatives. Starting from currently available resources various prospects can be realised. Finally, in postmodern society (1c) 'disciplining' originates from the future. Only one future is considered possible, to which present practices are subordinated. Future resources, rather than current ones, become critical.

Types of Social Cohesion

The crucial cement in traditional societies is constituted by what is tried and true. Everyday life is shaped by faith in what are well-tried routines, and by faith in those organisations and individuals that embody and/or express this faith most adequately. Social practices are ordered through such faith – similarly, the compass is oriented to the past via this faith in what is familiar and well-tried; thus the past is carried towards the future, via the present.

In other words, the habit of drawing on the repertoire of what is tried and true emerges here as one of the most important ordering principles (or, following Law (1994), one of the most important 'modes of ordering'). The normative frame – 'do as we always have done because it is right in itself – is the foremost medium for maintaining the continuity that connected past, present and future. It provided social cohesion.

In modernizing societies, this normative moment, which focuses on what is tried and true, is replaced by agency: the ability to realize one's own future projects.

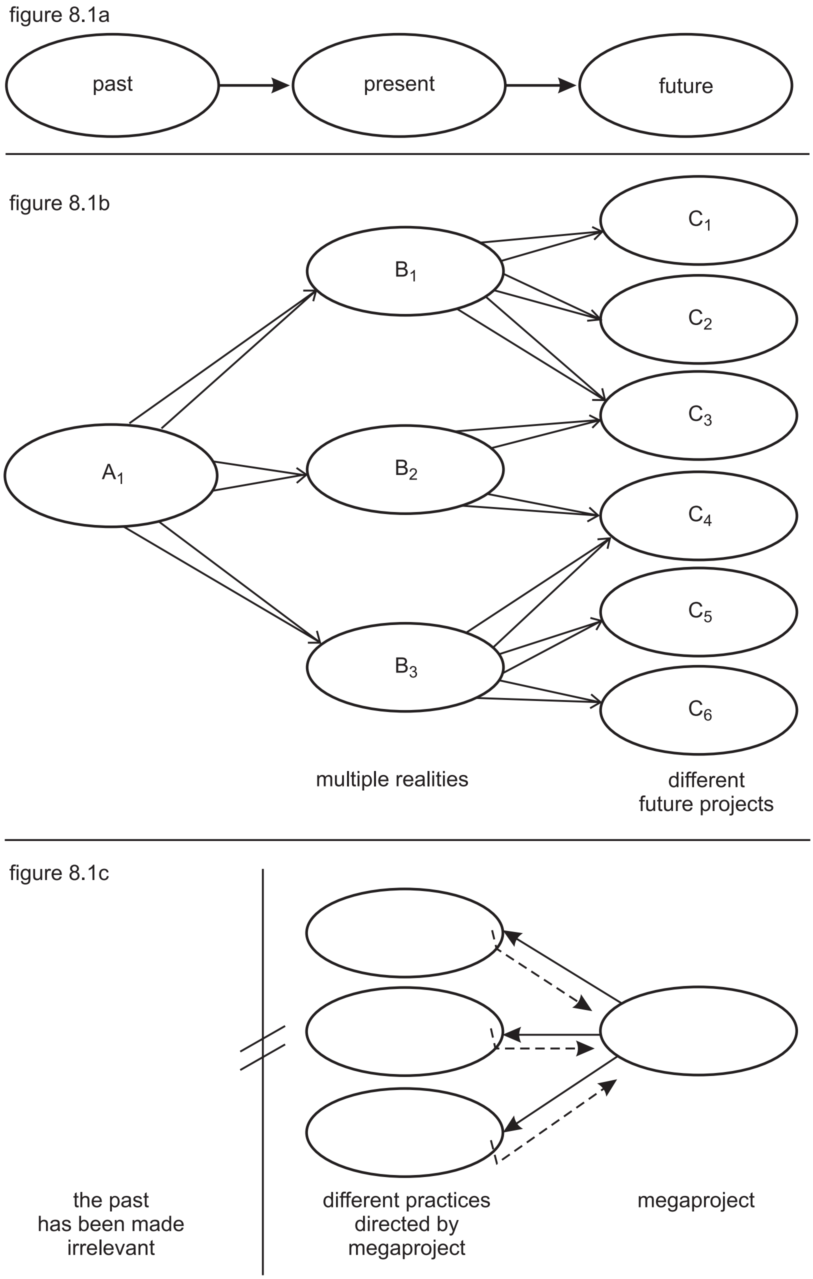

Figure 8.1 *The relations between past, present and future*

Here too faith is a vital ingredient, yet this is no longer the same faith that once was the cement of traditional societies. Now it is confidence in one's own knowledge and capacity. Integral to all this is confidence in the realization of new alternatives that build on the resources developed thus far and in the ability to develop the required connections with others.

Thanks to agency, the various projects of Figure 8.1b can be realized. The question of what is possible is always crucial. Knowledge (whatever the type) of new possibilities that reach beyond both what is well-tried and what is considered right becomes a decisive factor. Knorr-Cetina provides an accurate definition of the difference between these two phases:

> *Not only has order become a cognitive (including linguistic) rather than a normative phenomenon, it has also become a man-made rather than a man-coercing matter: it is produced, contested, repaired, organised and displayed in concrete situations whose definition became the subject of continual accomplishment and interruption* (1981, p6).

Increasing differentiation is characteristic of 'order as a man-made matter'. Available resources (both material and social) are unfolded and developed in increasingly different ways. Hence, different and mutually contrasting realities (multiple realities) emerge, each providing their own starting points for further evolution. Apart from the social, the material too produces an ordering effect.[6]

In retrospect, the high degree of institutional clustering that seems to rule the contemporary, postmodern world was largely absent in modernizing societies. At present a semi-coherent system of artefacts, rules, procedures, agendas and expectations – in short a technological regime (Rip, 1995; Rip and Kemp, 1998) – directs, informs and sanctions social actions to an extent that can almost be described as coercive. In contrast, a much more diffuse process of variation and selection was in operation during the modernization phase. New development opportunities (such as those represented in Figure 8.1b) were not judged a priori by the degree to which they were in alignment with dominant development projects. Variation originated from every nook and cranny. The evolving practices themselves formed the basis for the judgement of what was 'better' and what was 'worse'.[7] Variation increased and selection followed later. The selection was *ex post* and essentially made by the parties that were directly involved.

These ongoing processes of variation and selection merit further discussion. First, the unfolding of development opportunities – that is, the pursuit of particular development projects – should not be understood as a mere individualistic enterprise. Just as the actions (of any individual actor) can only be understood as the concomitance (interlocking)[8] of and/or distantiation[9] from different practices, individual projects can only be realized if they are founded in the required degree of coordination – that is, if they become part of a larger system of interlocking projects. Actor-networks are crucial in this.[10]

This is illustrated in Figure 8.2. Actor A only has a chance of realizing their specific development project if they succeed in realizing the essential convergence with B's and C's development projects at the right time. Say, B and C stand for the dairy industry and a neighbouring farmer, respectively. So far, A has had little to do with C (there is currently no interaction). However, since A's 'project' anticipates a

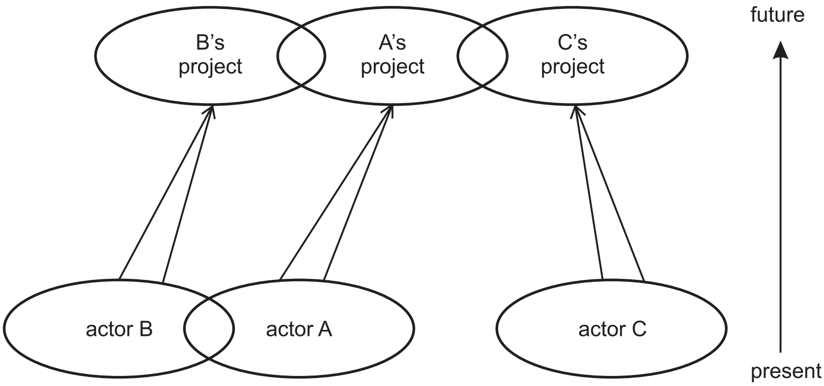

Figure 8.2 *The convergence of projects*

rapid expansion (more land, more quota, more room for ammonia emissions etc.), partly because this is expected by B, the future disappearance of C (and hence the transfer of development opportunities from C to A) can be crucial for the realization of A's development project.

The degree to which convergence of development projects is created thus emerges as one of the most important ordering principles.

> *Instead of being seen as a monolithic system which regulates individual action, order comes to be seen as an upshot of concrete, communicative interaction [...] Social order is not that which holds society together by somehow controlling individual wills, but that which comes about in the mundane but relentless transactions of these wills* (Knorr-Cetina, 1981, p7).

In the postmodern constellation, a new 'cement', a new mechanism for maintaining cohesion can be identified: trust.[11] Trust refers to the necessity to follow more or less implicitly, and to rely on, a system of objectified parameters defining rational versus irrational alternatives for action. In this context Galjart (1998, p13) speaks of 'trust in systems'.[12] As social cement, trust contrasts sharply with the normative and cognitive mechanisms discussed above. What may, and should be, proved is defined by new frames. The (decentralized) production of multifarious knowledge becomes replaced by a new approach: how to organize knowledge in a centralized way. This requires a particular carrier.[13] If collective memory and widely supported normative frames were initially important and later replaced by the capacity *to make a difference*, as supported by various and varying groups of actors – trust is accompanied by a new carrier, the expert system. That is:

> *a system of technical accomplishment [and] professional expertise that organises large areas of the material and social environments in which we live today* (Giddens, 1990, p27).

Figure 8.1c illustrates how a certain (as yet not existing) image of the future is specified within, and through, the expert system. Only later will the means and rules through which this image will be designed and implemented become evident. This realization takes place via the simultaneous coordination of various, apparently unconnected, practices. The extent to which such a coordination occurs depends directly upon trust, upon the supposed certainty that adjusting one's own actions to the specified image of the future achieves better results than diverting from the image.

The outcome of modern courses of action (see Figure 8.1b) is a highly heterogeneous world, a set of contrasting practices, which, due to a particular organization of interrelationships, collectively compose a system that is able to operate due to the realization of sufficient degrees of freedom for each of the discernible practices.

In the postmodern constellation (see Figure 8.1c), on the other hand, society tends towards uniformity. Since expert systems radically restructure the relations between 'the universe of the undisputed' and the 'universe of discourse' (Bourdieu, 1977, p168) and between what is and what is not allowed, a process of ordering emerges that puts great pressure on, or eliminates, the heterogeneous nature of social relations and practices.

Expert systems create a new 'domain of the undisputed', a new '*habitus*' (Bourdieu, 1990) of their own: that is, a world as it should be; not because there would be some sort of subjectivity or intersubjectivity, but because this 'world', this future, would be determined objectively by laws that are understood in and by the expert system.

Incidentally, it should be mentioned that in the creation of a heterogeneous world the phrase 'everything goes' definitely does not apply: the world cannot be moulded and shaped at will. Co-production and co-evolution always play a key role in the development of the various practices, that collectively compose a 'heterogeneous world'. I use these concepts to refer to the interaction between, and the mutual transformation of, the material and the social. Farming can be understood as a special type of co-production, precisely because here the material largely coincides with the living world.

The living world (animals, crops, soil, ecosystems in the wider sense etc.) is not only exploited by agriculture; it is also continuously unfolded, recombined, enriched and/or depleted by it. In short, the resources that are derived from nature, and which remain part of nature at the same time, are particularized in, and through, farming to contain new, always specific, possibilities but also new, again specific, limitations. In terms of Figure 8.1b: you cannot jump from B1 to C5 just like that. For example a high-yielding Holstein cow cannot suddenly be put on a low-energy diet. In summary, people draw their own boundaries in and through their interaction with nature (that is, through co-production). And where one considers jumping over the boundaries, it emerges sooner or later that the material, and certainly the living world, cannot be understood and treated as if it is as 'malleable as clay'.

Similarly, the social world has its own characteristics. Various examples will be discussed in the course of this book. They are partly related to the particular requirements resulting from co-production: not every form of social organization matches the particular kind of co-production and co-evolution in agriculture. Disregarding those particular requirements (a remarkable characteristic of current expert systems) can result in extreme disruptions and irreversibility (NRLO, 1997; Scott, 1998).

Finally, when expert systems become dominant, in the sense that they reduce the expanding set of future possibilities to one exclusive alternative, selection changes its nature. Then there is no longer concern about an *ex post facto* selection, but rather about an *ex ante* selection: only those actions that correspond with the preferred future count as valid. All the others become delegitimized from the very start. It goes without saying that this has radical and highly negative effects on the production, and maintenance, of variety.

Time, Structure and the Social Sciences

Just as every revolution is decorated with the colours and symbols of the previous revolution (Groen and De Buch, 1968), the social sciences try to unravel existing constellations by using concepts that were developed to understand the previous ones. The modernization period – characterized by its highly differentiated nature, by a process of simultaneous unfolding of various, contrasting projects (see Figure 8.1b) – is usually approached with a concept of structure derived from, and corresponding more closely with, the previous, traditional situation. Central to this concept of structure are causal complexes, which precede certain outcomes (see Figure 8.1a). Because a certain cause cannot produce contrasting effects, the explanation of heterogeneity (see Figure 8.1b) becomes an almost insoluble problem from the outset.

The same is repeated under postmodern relations. Attempts are made to understand practices that are increasingly standardized, if not 'caged', by the dominance of the expert systems (see Figure 8.1c) through the application of an adage better suited for the modern era: 'agency is going beyond structure/structure follows action'. Again, a major problem arises; that is, to understand how convergence, homogenization and coercion increase in an apparently free world.

In all societies, regardless of time and space, regularities and recurring patterns emerge. These regularities constitute the blessing and the curse of the social sciences. They constitute the starting point, but often also the Waterloo, of the enterprises of economists, sociologists and historians.

Such regularities, irrespective of where they occur and of their nature, always lead to a set of interrelated questions, which I will briefly summarize here.

1 To what extent are the observed regularities absolute? What is the importance and relevance of the exceptions, the 'black swans', which, on careful inspection, can generally be found as well? And subsequently, what influence (if not bias) do the methods have with which we construct these regularities? How do we get to determine regularities at all?

2 What do these regularities mean? Do they mark out the undisputed from the discursive, the fixed from what might still be variable? Do they refer to a frame in which human action and, more generally, social development necessarily has to take place?
3 What do the occurring regularities refer to? Do they offer information about underlying structures (irrespective of their nature) imperatively directing human action (and hence social development)? Do they refer to cause–effect relations with which the observed (or constructed) regularities can be regarded as resulting from underlying causal complexes? Or are they rather the expression (and/or representation) of temporally and spatially bounded conventions, which should be considered as fluid and variable?
4 More precisely, how do the different regularities, the different conventions, relate to each other? And maybe even more importantly, what role does our ability and/or inability to gain control over the occurrence of regularities play in the actual ordering of the world?

Social practices contain certain regularities. They follow certain patterns, a certain logic, resulting in a certain course, a certain pattern, becoming self-evident truisms: 'that's just the way it goes'. Observers of the agricultural sector will come across countless, and often impressive, examples of regularities. These are usually examples that reach far beyond specific locations in time and space.

Whatever the place or time, agriculture is generally organized into small units, which we define nowadays as family farms – that is, units in which labour and capital are combined in one and the same person. Farm men and women are not only owners of most of the means of production, they also do most of the productive work. Management as an isolated factor is absent: mental and manual labour are combined in the same person. All this constitutes a remarkable contrast to the industrial organization in the urban economy (Braverman, 1974) where design and implementation, mental and manual labour are usually separated, as are the ownership of the means of production and the realization of the actual labour and production processes.

Other regularities are more confined in terms of time and space. There are periods in which farms are systematically and purposefully reduced in size (Staatscommissie, 1912, pp477, 492), whereas in other periods there seems to be a universal tendency towards farm enlargement. These seem to be almost general processes within the boundaries of the period in question. Someone who looks further into this will recognize the particular and the temporary.

Similarly, regularities are spatially confined. Hayami and Ruttan (1985) show, in a comparative analysis at the global level, how there is ongoing intensification in certain regions, while scale enlargement emerges as the dominant development pattern in others, and stagnation is most striking in others. A similar spatial differentiation can be found even within the European Union, where similar economic relations increasingly apply and where new technologies are basically accessible to every one (Van der Ploeg, 1991, p65).

Why do regularities exist at all? What are their roots? What exactly do they consist of? And why does one pattern sometimes replace another? These essential questions are asked repeatedly within the social sciences and many answers have been offered. In this book I will try to relate these questions to the way in which past, present and future are connected.

Regularities are, to summarize a large part of social science theories, the outcome of a certain ordering: the result of an ordering that, it is often assumed, is produced in the last instance by a certain structure. There are, to summarize further, certain, clearly definable and identifiable structures that order human action, i.e. different social practices.

Structures form the guiding principles for action, they lead action in a certain direction. Hence, regularities emerge, which in turn constitute an argument for further (conformation of the already introduced) ordering: indeed, 'that is just the way it goes'. One can try to set up an industrial farm (based on labour – capital relations), one can try to escape the necessity of farm enlargement, but sooner or later such attempts will fail. The course of history – structural development, as one says in agricultural circles – is irreversible.

Alongside the question of where to locate such a structure (within the predominant mode of production, in the system of norms and values inspiring and informing human action, in the system requirements inherent in every society, within the combination of opportunities and limitations contained in every situation, within the relations situated in markets, in the development of technology, or within the combination of technological and economic development?) the question of how to imagine such a structure emerges. In essence, the latter question leads us to the relation between cause and effect, to the interrelations between past, present and future.

Within the space of this section it is almost impossible to do justice to all that has been said about this issue (for an excellent discussion about the structure concept in agriculture, see Benvenuti, 1990). Therefore, I will confine myself to a simple contrast: the image in which structure is represented as a *skeleton*, as the carrying framework, versus the concept of structure as a *process of ordering*, as that which is being built.

A favourite image represents structure as being like a skeleton. Just as a skeleton shapes the human body (at most one can be fatter or thinner), structure shapes human action. In other words, action is conditioned by structure: certain actions are possible, others are ruled out. I will never be a sprinter with my hip dysplasia.

Apart from the analogy with the human body, reference is frequently made to large-scale constructions: a modern high-rise block of flats contains a framework, a skeleton made of reinforced concrete (Giddens, 1992, pp19, 731). The framework is fixed. Within the possibilities of the framework, only certain rooms and arrangements can be created.

In short, structure is coercive. Certain possibilities are ruled out, while other possibilities present themselves as obvious. Furthermore, structure precedes subsequent actions. Action is determined by structure; and structure precedes action. Hence, structure is in essence external to action.

Structure as process of ordering

As indicated in Figure 8.1b, certain realities contain certain development opportunities, while ruling out others at the same time. In essence, it means that the mobilized resources are shaped, are differentiated, into particular resources. In plain English, a beef cow is not a dairy cow, and it is impossible to change her into a dairy cow overnight.[14] The same goes, for example, for the craftsmanship of a beef farmer; it differs remarkably from a dairy farmer's. By implication, there is little use in abruptly replacing the herd (selling beef cattle, buying dairy cows); the necessary craftsmanship will still be missing. The same applies to the capacities (the 'abilities') of the actors involved: they know how to realize, utilize and further develop certain matters, but not others. And finally, the networks: there are certain relations that can be built upon, while other relations are missing and cannot be developed just like that. It is questionable, for example, whether a dairy factory is willing to accept a new supplier, especially one with no experience of dairy farming.

Further illustration will not be necessary. A particular constellation has been built up, including networks, resources and actors (often summarized in this context in terms of socio-technical networks);[15] a particular 'system' that contains its own development opportunities and rules out others. This particular process of ordering directs and shapes future-oriented action to a large extent, but not so much in the classic, determinist sense. What orders (or 'structures') here is the already constructed practice, not something external to that practice.

Similarly, the situation of the beef farmer (I use the example one more time) contains various distinct possibilities. He or she can gradually develop their farm towards high-quality cattle (focus the use of his resources into one direction) and develop the networks necessary to pursue this goal. However, other options will present themselves too: to continue beef production whilst sharply increasing its scale, et cetera. Whatever alternative is chosen (can be chosen), the process of ordering will always be continued. Ordering is an ongoing process, and a process that largely directs itself. I have summarized this again in more detail in Figure 8.3.

Of course, the unfolding of development opportunities, the realization of a particular project that builds on what is already realized, does not happen in isolation. Whatever possibility is pursued and realized, interactions with the development projects of others will always be at issue. Frequently this will be translated through abstract, depersonalized categories. For example, what developments are taking place in the markets? Of course, these issues are taken into consideration in the unfolding of one's own project. External developments are followed, interpreted and translated into one's own actions, into further-reaching processes of unfolding.

Again we have to conclude that this does not involve unidirectional determination. Not everyone has made himself equally dependent upon external developments, upon other projects. Some meat producers, for instance, will have made extensive use of external funding. They have let their own development project

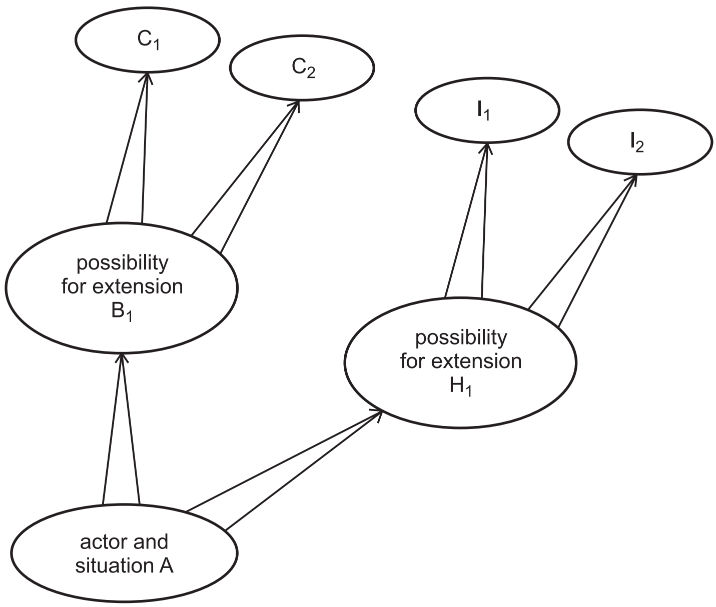

Figure 8.3 *Ongoing process of unfolding*

converge largely with the particular development projects of banks. Consequently, in case of further expansion they have to take account of the parameters applying to capital markets and of the requirements of the funding organizations. This will not apply to other meat producers who have based the construction of their farm on their own savings and/or family capital, or if it does apply it will be less significant.

Analytically, integration and distantiation thus become important key concepts. In more general terms, the network of relationships connecting different projects becomes decisive in the further construction of practices. What is important to note here, however, is that the nature of these networks can vary considerably.

In a way current practices constitute the result of former processes of unfolding. In turn, these practices (the particular and fine-tuned systems of resources, capabilities and networks) direct and order the further processes of unfolding, which will undoubtedly leave their mark on subsequent possibilities and impossibilities. That which has been constructed in a certain practice structures the further development of that practice. Hence, regularities emerge: patterns of coherence and continuity. In turn, they refer indeed to something that orders, to something that structures. In other words, there is absolutely no need to deny that 'actors' choices can be constrained' (Harriss, 1997, p11).[16]

Essentially, that which structures is not external to, but inherent and implicit in, the practices themselves – that is, in the practices that the actors involved realize themselves, in mutual interaction with others and with other things. In essence outside of these social practices (in their broadest sense) there is no other structure that orders these practices as a given 'skeleton'.[17] The structuring element is contained in the practices themselves: in the unfolding and, therefore, in that which is unfolded. To unfold is to structure, and structuring takes place through processes of unfolding. This is not to deny the influence of distant practices, of practices situated elsewhere, or the influence of 'interactive systems over which they [i.e. the actors involved] have little control' (Booth, 1994, p39).[18] In so far as such 'interactive systems' (or 'networks' as I have defined them above) and external parameters, such as the interest rate, given in the previous example, exert any influence this will occur through the interaction between the 'internal' and the 'external' – never unilaterally and deterministically from the 'external'.[19]

Agency – the capability 'to make a difference' – and networks are two essential concepts in the development of a non-determinist concept of structure as construction, of structure as situated, and inherent, in social practices – hence, of structure as a heterogeneous and evolving phenomenon.

The concept of agency occupies a prominent position in contemporary sociology. According to Giddens:

> *Agency refers not to the intentions people have in doing things but to their capability of doing things in the first place... Agency concerns events of which an individual is the perpetrator, in the sense that the individual could, at any phase in a given sequence of conduct, have acted differently. Whatever happened would not have happened if that individual had not intervened* (1984, p9).

In other words, agency is the capability to make a difference, the art of changing the course of events; the capability, in summary, to turn one's own situation into something different, into something that would not have existed, or that would have been different, if the actor in question had not intervened.

What does this 'capability of doing things' depend upon? The problem with Giddens' definition is that too much emphasis is placed upon the individual. Agency expresses itself nearly always as a manifestation of several actors and explicitly not as something of which the 'individual is the perpetrator'. Even if it involves only one individual, the action expressing his or her agency should absolutely not be considered as an individualistic action. An individual only displays agency in interaction with other people or with other things.

Second, it is not clear from the quoted definition (which applies to Giddens' oeuvre, *tout court*) what it is an actor draws from to realize agency (hence there is little left but to represent it as a somewhat mythical individual attribute). What resources are mobilized to produce agency?

A more adequate description that addresses this problem, is presented by Long.

> *[A]gency attributes to the individual actor the capacity to process social experience and to devise ways of coping with life, even under the most extreme forms of coercion. Within the*

> *limits of information, uncertainty and the other constraints (e.g. physical, normative or politico-economic) that exist, social actors are 'knowledgeable' and 'capable'* (Long and Long, 1992, pp22–23).

Agency is made concrete in this definition, especially by pointing out what it relies on and builds upon: the capability to process and utilize the experiences gained thus far and also the capability to face existing and/or imminent difficulties (it should be noted explicitly that these difficulties are of a social nature – that is, concern the interrelations among actors and between actors and things). *En passant*, I want to mention that agency is discussed here as something that 'is attributed' to the individual actor, which implies that agency does not necessarily have to be rooted in or stem from the individual – even if it seems that way.

Third, when we speak about agency we should also mention its opposite ('non-agency'). Alongside the capability to make a difference, the opposite, incapability, also frequently occurs.[20] Without the latter, we cannot define the former.[21] Without non-agency as a conceptual and empirically manageable counterpart, agency becomes a non-concept.[22] A number of the issues raised here can be solved by involving the future-oriented nature of social action explicitly in the analysis. I will do this by way of Figure 8.4, which builds upon Figure 8.3.

Effective unfolding (from the initial situation A) along the first track (from A to C_1 and subsequently to C_2) is only possible if C_1 and subsequently C_2 can be effectively woven into the required relations. If we consider C_2 as a project in which strategic and future-oriented actions are united, C_2 can only be realized if coordinated and actually interwoven with other relevant projects.

> *Par définition, un projet … est une fiction, puisqu'au début il n'existe pas* (Latour, 1991, p155).

The essence of a project is that it does not yet exist, but that it has still to be realized. Let track 1 be the above-mentioned quality option of the beef farmer (the example returns once more). It will only be possible to realize this project if it interlocks with various other projects (first with X_1 and Y_1, subsequently with X_2 and Y_2). Groups of consumers will have to be interested in high-quality meat; they will also have to be able to recognize this. Butchers will have to be willing to distribute the meat as a distinctive product. Abattoirs are needed that are willing to slaughter an, initially, limited number of animals. And so on.

It might be possible to think of alternatives (for an empirical sketch describing production, processing, distribution and consumption of beef from nature reserves, see Kuit and Van der Meulen, 1997; Ventura and Milone, 2000). However, it remains to be seen whether these alternatives correspond with the way in which government implements and enforces hygiene regulations – which, in turn, could depend heavily on developments in the agroindustrial complex. More generally, it is highly conceivable that X (for example, the agroindustry) and Y (for example,

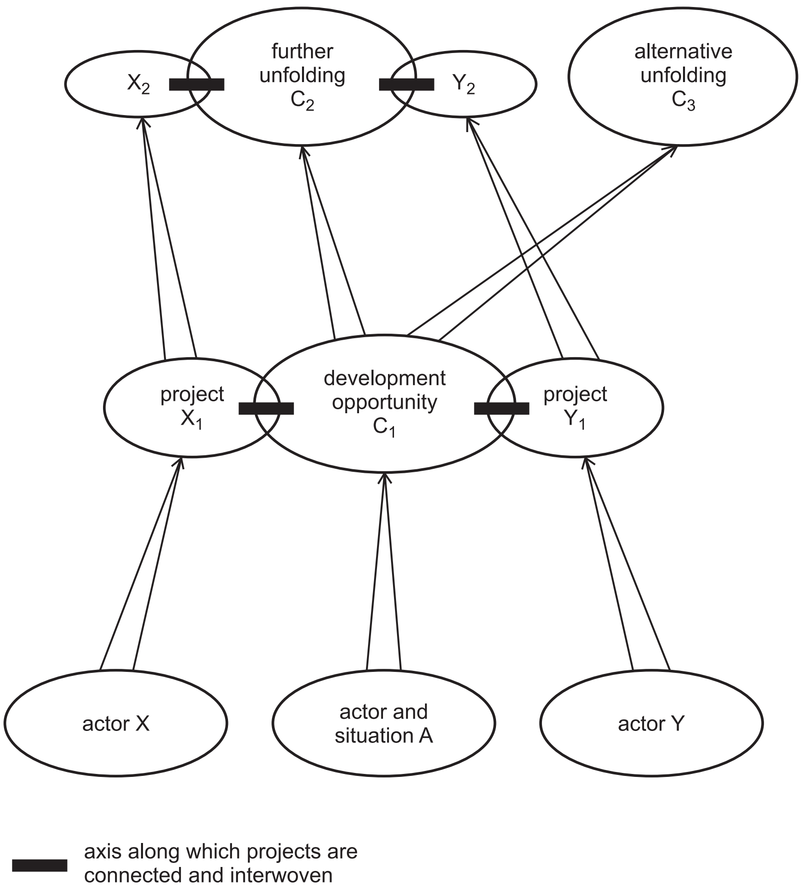

Figure 8.4 *The interaction between projects and the construction of networks*

government) establish their positions (X_1 and Y_1 and later X_2 and Y_2) to such an extent that actor A is left with only one trajectory (for a general view, see Burawoy, 1985; and with regard to agriculture, see Benvenuti, 1982, Benvenuti et al, 1989). Thus it becomes, for example, impossible to realize C_3 – unless actor A can actually develop mechanisms to distance himself from X_2 and Y_2.

'Realizing things' (of any nature) always happens through others, although to a varying degree – through other actors, through institutions, through artefacts etc. An 'actor-network' is needed: a set of precise (i.e. not accidental) relations with others, through and within which one's own 'project' can be realized. Through an 'actor-network' one's own project can be carried out, because through this network the project is connected to the projects and procedures of others. Such a network explicitly involves the 'social' (it includes other actors and institutions), the 'material' (it contains particular resources, artefacts and transactions) and the interaction between the two.

What then is agency? Agency is the capability to anticipate the necessary interaction and synergy of various projects – the capability to develop one's own project in such a way that the chance of actual synergy, of an 'interlocking of projects' (Long and Van der Ploeg, 1994, pp80–81), is as strong as possible. Hence, agency is also (and perhaps especially) the capability to interest and involve others in one's own project, the capability to encourage others to further unfold their projects in coordination with one's own. In other words, agency is the capability to create an actor-network. Only by doing so, is it possible to make the proverbial 'difference'.

Furthermore, agency is the capability to actually realize the initially *imagined* constellation (the set of 'interlocking projects' around C_1). The more and better anticipated, the more carriers of other relevant projects will become interested and involved, and the more and better the road to C_1 becomes effectuated. The more agency there is, the more capability there is to 'make a difference'. The less this applies (to whatever subject), the less agency there will be; hence, incapability emerges.

Initially, the network around C_1 is a virtual network (a 'prospective structure', according to Van Lente and Rip, 1998). The network is, as yet, only imagined. However, this does not make it less real, for it is above all real in its consequences.

Agency manifests itself through initially virtual networks; networks that are subsequently realized (or not). Therefore, agency should not be considered an individual quality. Whatever it is that I imagine and consider, does not in itself help me realize anything.

Agency is first of all dependent on the extent to which a virtual network can be imagined and, subsequently, can be constructed and extended. The individual actor emerges only in the second instance, in so far as he or she has the capability to contribute to the constitution, specification and realization of the intended set (the network) of 'interlocking projects'. Again, the role of the individual actor can only be understood in relation to the thoughts and actions of other actors – and definitely not in a strictly isolated, sheer individualistic sense.

What turns the commotion and goings-on of the human enterprise into agency? What is the ordering principle? What is the structuring moment? The answer is simple. The fluid and continuously changing concepts[23] with which groups of actors imagine the future – the *virtual* networks of intended future projects, whether or not attuned to each other – are structuring action. 'Commotion and goings-on' become agency in so far as they result in virtual networks that actually mobilize, inspire and cause realization. All action is future-oriented action (even though it appears to be different sometimes). Future-oriented action is structured via and by way of virtual networks – networks imply agency and at the same time define it (in a more concrete sense).

I claimed above that no structure exists beyond social practices (I should say socio-technical practices). Structure is immanent in social practices. That which structures is implicit in social practices as the way in which ordering occurs. How this process of ordering occurs is described here in a general sense: via the indicated virtual networks. Hence, structure is localized, agency is specified, which explains why the concept of structure is partly actor dependent and partly not; moreover, structure – that is, that which appears to be structuring – is the outcome of agency. At first this seems incomprehensible (and within the accepted Giddensian theories it cannot be but nonsensical), but it becomes plausible as soon as we integrate the time dimension and the importance of virtual networks into the analysis.

> *Networks, routinisation, and institutionalisation*
> *[A] network refers to a set of direct and indirect social relations, centred around given persons, which are instrumental to the achievements of the goals of these persons, and to the communication of their expectations, demands, needs and aspirations* (Anderson and Carlos, 1976, p28).

In this description, Anderson and Carlos stress, surprisingly, the orientation to the future – that is, the virtual nature of networks.

The concept of social networks was developed initially by anthropologists such as Radcliff-Brown and Mitchell (1969). Their direct intention was a better understanding of society in terms of 'fabric' and 'web of social life'. What keeps society together? What gives cohesion to, and connects, the commotion and goings-on?[24]

The social relations of which individuals are part can be analysed as a network (Boussevain, 1974, p25). A social network is more than a communicative structure, for many messages consist de facto of transactions – transactions that explicitly concern the material. In short, it concerns *socio-technical networks* (Wiskerke, 1997, p1). This applies a fortiori to the above-mentioned virtual networks.

In premodern constellations one would hardly, or even not at all, be aware of the extent to which the construction of the future occurs via virtual networks. The goals that those involved aim for, and more importantly 'the set of direct and indirect social relations' (the network) supporting the realization of the goals, are all largely routinized. Today's goals, and the social relations important for their realization, are the same as yesterday's. It is as if thinking is not needed. One can steer by the compass of the well-tried and proven. The required network does not seem to be virtual. It is the network that has always been there. 'That is just the way things are.' Having unshakeable faith that things would happen just like they did before, one could face the challenge of the future.

The most fascinating – and unusual, but no less adequate for that – critique of traditionalism and its routinization stems, surprisingly, not from science but from literature. This criticism is from Jean Auel (1980), who sketches the ins and outs of the 'clan of the cave bear'. The members of this clan act on the grounds of routine. The tried and true is the measure of (future-oriented) actions. Because the members of the clan increasingly, and despite themselves, gain *new* experiences, however, they have to remember more and more. Consequently, their heads become larger, the essential brain size intended for the required memory increases. This results in more difficult child births. The heads of the newborn babies, brimful of and hence swollen by collective memories, become too large. Therefore the clan becomes extinct. 'They didn't know it, but their days on earth were numbered, they were doomed to extinction' (Auel, 1980, p503).

In the modern period the creation of variation becomes an established, if not self-evident, phenomenon, resulting from the ubiquitous search for innovations and improvements. Of course, certain types of division of labour accompany this: not everybody can carry the risks inherent in innovation (see Hofstee, 1985). Similarly, (experiential) rules apply, structuring the process of innovation. Ironically, the smaller the proportion of what is potentially changeable, the higher the chance of success (Herrera, 1984).[25] Innovation is explicitly understood as a quest. This is typically expressed by the subjunctive, as explained by Van Kessel in a fascinating essay:

> *The subjunctive … is oriented towards the universe of possibilities, to everything that could exist in society* (Van Kessel, 1990, p92; see also Darré, 1985).

Talking and thinking about changes does not involve security but rather insecurity. Hope and desire constitute the most important guidelines; hence, the subjunctive mood. This grammar is in sharp contrast with the grammar of the previous, traditional period, characterized by the imperative, and especially with the grammar of the postmodern phase, in which expert systems use the indicative, which refers to the way reality merely *is*. This involves a highly objectified ('it is the case that …') and nomological language ('if this, then that'; see Koningsveld, 1987). Also closely related to the subjunctive, which is so typical of innovation in the modern period, is modesty: the success of an intended innovation depends on many elements that collectively compose the socio-technical network. Van den Berg (1989) gave his study about agriculture in the Peruvian highlands the meaningful title: *La tierra no da asi no mas*. The Earth does not give without difficulty – you cannot impose just anything upon her, let alone demand and expect just anything of nature and the living world (see also Salas, 1996). Looking back, this modesty (recognizable in many places)[26] is in striking contrast with the pretensions with which the process of innovation is positioned and legitimized in the postmodern period – but I will leave this aside for the moment.

Looking back, various other features can be recorded. It is remarkable that innovations almost always start at a small scale. This not only reduces the risks involved, but it also enables 'learning by doing' (Dosi, 1988). The initial small scale is partly related to the situation of utilizing mainly, if not exclusively, one's own resources (one's own land, own labour, own knowledge, own savings, own networks etc.). The latter feature, in turn, reinforces the multiformity of (potential) development routes, explored and realized through experimenting and innovating (Osti, 1991). After all, the specificity of the already present resources (irrespective of their nature) cannot but lead to multiple modes of unfolding (Jollivet, 1988).

In summary, the process of innovation as it occurs in agriculture under 'modern' conditions implies a clear balance. The development of new constellations ('new realities'), such as C_1 in Figure 8.4, assumes the creation of new (or more clearly specified) resources, and also of new combinations of resources and new (or at least partly new) networks. As a project, C_1 is (that is, from the position of the here and now, i.e. seen from A's position) a *virtual* reality. It is not there yet, but it is, presumably, possible to create it.

At the same time, this very *confidence* makes the project into much more than a merely virtual whole. It inspires actions in the here and now (at A in Figure 8.4) but also in the future and probably elsewhere too (see X_1 in Figure 8.4). It can and will also inform and inspire the actions of others, certainly if the project in question radiates sufficient authority and persuasion to create faith, to establish the necessary network (X_1-C_1-Y_1) in the future (C_1). Hence, there is an essential balance between, on the one hand, what is new, what is unknown, what is still to be realized and, on the other, the thus far constructed set of resources and what is knowable and controllable.

In other words, innovation is not the abrupt reorganization of what exists (for an applied analysis, see Van der Ploeg, 1993). Here, innovation represents the art of creating something new by making as much use as possible of the existing (see, for example, Brush et al, 1981); however, it needs mentioning that the 'existing' does change, precisely because it is fitted into a new, relevant whole. *Voilà*, the paradox of the innovation process: the less virtual the networks, the higher the chance of creating them and, hence, new 'realities' (such as C_1). The tension between possibility and reality is essential for the innovation process, but a careful 'monitoring' of the tension is equally essential. Just like an elastic band, it cannot be allowed to break.

At this very point, one of the central differences between 'modern' and 'post-modern' constellations emerges (between Figure 8.1b and Figure 8.1c). The definition of macroprojects (or 'megaprojects', following Scott's terms) by, and from the position of, one or more expert systems is crucial (see Figure 8.5). Such macroprojects are pre-eminently virtual. They are in principle disconnected from the identities, resources, projects and networks that apply here and now (at moment X). Here the balance between what is virtual and what is real, so typical of the modern constellation, is largely if not completely absent. Hence the intended innovation can only take place as a comprehensive reorganization.

In this book, I will discuss such a macroproject[27] at length: the reorganization of agriculture according to the models developed in the expert system in and around agriculture. I use the metaphor of the *virtual farmer* for this. The 'virtual farmer' is an image developed in the expert system. It concerns the farmer (or grower) as s/he should be and should function according to the assumptions that are axiomatic within this expert system. The same metaphor also refers to agriculture as a whole – at least, as it should be – and to farms as they should be.

The virtual farmer refers to the 'one order world', to the only conceivable, rational model towards which the actions of a wide range of actors, of government, of banks, of agroindustries, of farm men, of farm women, of advisory services and research centres and so on, need to be directed.

Hence, the virtual farmer also defines a network, a virtual network. However, the latter network does not contain a balance between reality and possibility, it is completely virtual. It does not consist of the unfolding of the potentials contained in the current reality. On the contrary, a rupture emerges: the development opportunities are replaced by the new, virtual macroproject. This macroproject directs and sanctions the actions of various actors in and around the expert system in an almost coercive manner (see Figure 8.5), in such a way that, on the whole, the intended reorganization materializes. Hence, the macroproject implies *trust*, the essential cement assumed in a constellation such as that sketched in Figure 8.5. A virtual network can only function by the grace of trust – that is, by the grace of faith in the prospect suggested by the expert system. Also, it can only function in so far as various unintended consequences of the macroproject can be controlled and/or externalized.

The realization of a macroproject can only happen via and as a comprehensive reorganization. This implies that variation and selection cannot happen via the multiple unfolding of various realities. Here selection is no longer part of the development process: selection becomes a one-off and occurs *ex ante*.

Alongside macroprojects, other alternatives are implicitly or explicitly interpreted as inferior; and as undesirable, because the realization of other, competing alternatives cannot but be an intrusion on the intended comprehensive reorganization, reducing the efficiency of the operation as a whole. Similarly, a partial realization of other opportunities refers to an insufficient degree of trust; the virtual

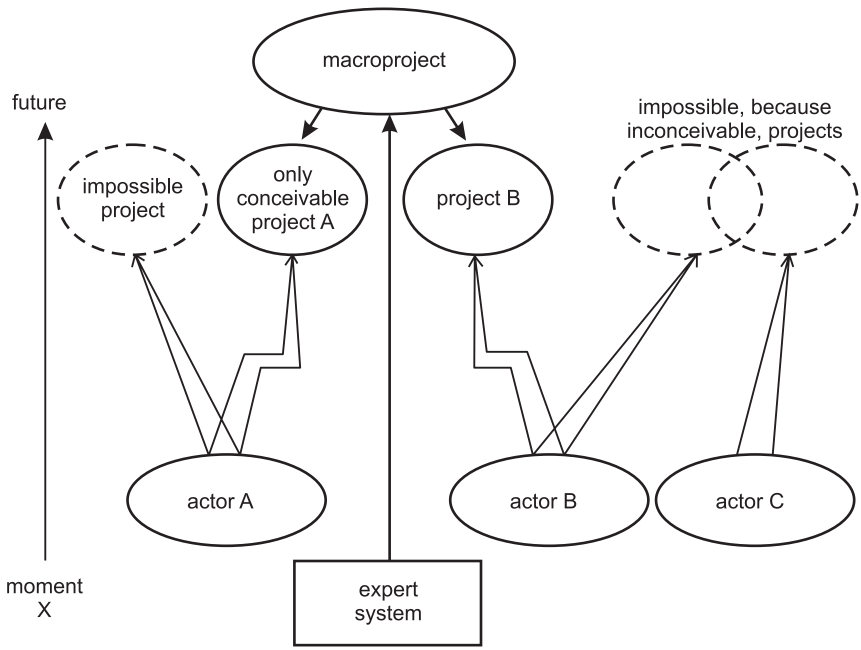

Figure 8.5 *The directive role of macroprojects*

network would be incomplete. In summary, variation is thus significantly reduced from the beginning.

En passant, this points to the essential differences in scale. The intricate types of development, characteristic of the modern constellation, will be relatively small in scale because of the reasons briefly touched upon above, especially in the initial phase of conceiving, experimenting and innovating.

In a postmodern constellation, on the other hand, the realization of macroprojects implies almost by definition a large scale. Not for nothing, system innovation has become a catchword. Various other implications arise from this difference in scale. I refer to two effects here. First, transformation costs will be very much higher, not only because of differences in scale but also because of the generally high degree of disconnection from the existing situation. The macroproject does not build upon the resources, networks, identities and opportunities inherent in the existing situation (X) as described in Figure 8.5, but represents a rupture.

Second, a 'democratic issue' of a completely new order emerges. Realization of the macroproject leaves little opportunity for discussion and learning, whereas multiple unfolding provides more room for the insights and choices of the different actors themselves. While existing and virtual networks coincide within traditional constellations (because the future can only be imagined as repetition of the given) and while modern constellations consist of an undeniable tension, of a carefully managed balance between both types of networks, in postmodern constellations one finds the *other* extreme. Just as, in general terms, the future dominates the present, in a more specific sense, virtual networks come to dominate the current networks and practices. In agriculture, this becomes strikingly clear in the fact that those who define and materialize the future (the macroproject) are completely different actors than those who constitute the current relevant networks in and around agriculture. Alongside these complications, there is another, central, paradox. Conceptualizing innovation is no longer difficult. The expert systems are well up to this job. On the other hand, realization of the imagined innovations (the intended macroprojects) becomes one of the main, if not the central, problems. Here capability and incapability emerge again as two, closely related, themes.

Finally, an observation about the often extreme degree of 'institutional clustering' arising in postmodern constellations in and around these virtual networks. Innovation revolves, in essence, around the recognition, realization and utilization of new possibilities. New possibilities (that currently do not exist but that could exist in future) are the pre-eminent resources in the postmodern constellation (one could say, with some irony, that resources too have become highly virtual). However, by way of large macroprojects, such as those developed by different expert systems, this future has already become highly parcelled out by the state. The future is divided into fields that are considered to be conceivable, realizable and legitimate and into other fields that are considered to be inconceivable, unrealizable and illegitimate.

Hence, in the postmodern constellation, the virtual network is highly institutionalized. With respect to various future projects (irrespective of their nature) particular government organizations function as gatekeepers. A constantly expanding set of rules and procedures is developed to this end. The realization of different future projects (surfacing in civil society) is only possible in so far as they correspond with these procedures, in so far as they provide support for the gatekeeper, or, more generally, in so far as they are in line with prevailing macroprojects.

From this point of view, the state is, above all, a complex machine that seeks to prevent its parts from entering (for whatever reason) into hasty arrangements: the meetings, the endless consultations, the mechanism of initialling (all divisions and departments involved have to agree), the mechanism of co-funding, the procedures and calendars all function to eliminate every possible deviation from the prevailing macroproject (and, at the same time, to orient all possible resources and networks towards the macroproject in question).

The effects are threefold. First, the so-called transaction costs (the costs that have to be made to make something happen, to get something done) increase often to extreme levels. Second, the rules, procedures and gatekeeper functions often gain an independence that reaches far beyond the initial macroproject. It is possible for a macroproject to have long lost its meaning and importance, while the rules and procedures retain their own power. This can lead to grotesque events: important innovations remain unnoticed or are hindered. During the past ten years, I have witnessed extreme examples of this. Innovations that emerge outside of this expert system are regarded as suspect – as undesired competition, even if only in a symbolic sense. Hence, numerous potentially valuable innovations remain marginalized, restricted to the proverbial proportions of 'hidden novelties' (see Van Lente and Rip, 1998).

I came across a different expression of the same tension through the so-called 'commissions of wise men' of which I was part several times (probably by mistake). Such commissions are generally launched in The Netherlands when implementation of the prevailing regulations leads to almost insoluble problems and conflicts between those involved. To a researcher, these commissions constitute an exceptional research method as well as an extraordinary learning experience. One of the things that I have learned from them is that the solution, the way out of thorny problems (irrespective of whether they are concerned with the ammonia question in south-east Friesland, the national ecological network and the Gaasterland uprising,* or unemployment in the north of the country),[28] is often very simple in theory (because it assumes at the most a flexible interpretation of rules and above all a clear focus on objectives). The complication lies in sidestepping the prevailing procedures, arrangements and (bureaucratic) identities in ways that do not set a precedent or mean that the civil servants involved lose face.

This takes me to a third complication. This is the 'democratic deficit' brought about by, and effectuated in, this procedure. The *trias politica* – the separation of

* *Translator's note*: The realization of the national ecological network was initially imagined as a massive expropriation of farm land in order for it to be converted into a nature reserve. In Gaasterland, the entire population (including the non-agricultural population) protested against and effectively blocked this approach.

powers, at one time the basis of our polity – becomes increasingly lost as a result of the institutional clustering. Increasingly one and the same group of highly specialized and highly gifted civil servants are responsible for (i) developing the rules that regulate the workings within a particular socio-material domain (for example ammonia emission and deposition), (ii) providing for the 'right interpretation' of these rules and (iii) deciding when the rules are violated, or not. In short, even though the term 'postmodern' constellation seems to suggest a more or less definite, or at least superior, mode of social ordering, as yet things do not function at all smoothly.

The coordination of projects

With a view to the empirical analysis of the differences discussed here between multiple processes of unfolding, on the one hand, and macroprojects, on the other, we need an adjusted vocabulary, a set of interrelated words and concepts, which, on the one hand, does justice to the outcome of events while, on the other hand, being fundamentally non-determinist (Knorr-Cetina, 1996).

One of the concepts of great importance here is agenda-setting (Rhodes and Marsh, 1992; Baumgartner and Jone, 1993; Kingdon, 1995; Just, 1998). That is, defining the situation, specifying problems, indicating directions for solutions, and hence identifying the resources that have to be mobilized in order to implement the intended solutions.

Agenda-setting is not a neutral activity. Crucial issues are who is to join in the discussions, and who will be excluded.[29] Joining in the discussions provides the opportunity to influence the agenda: it gives authority and, conversely, only authoritative persons are invited to join in the discussions. As such, an agenda represents authority. An institutionalized agenda influences the thinking and acting of others – even when there are no face-to-face relationships; in that case we can only speak of 'control from a distance'.

What is authority? Authority, you could say, represents insight into, and overview of, the relevant whole – that is, knowledgeability and capability. For this reason, and also because of the related capability to subsequently arrange events according to this insight and overview, we can define authority as a type of agency. It is not, however, an arbitrary type of agency but rather one that is generally recognized. Again, this makes clear that agency is not an individual attribute. It emerges in and is brought about by networks.

Control over and mobilization of resources deserve – as do agenda-setting, authority and networks – a prominent place in the vocabulary with which structuring or ordering of social practices can be understood in a non-determinist sense. However, it is essential that resources are not taken at face value.

Speaking straightforwardly, a certain area of land, a number of cows, a shed with adjacent buildings, a certain number of labourers (or whatever) do not represent resources, either intrinsically or collectively. Material and/or social elements become resources only in the case of a more or less explicit model, in which they are congruently forged together into a working and sufficiently promising whole, into a solution, a vision, an expectation.

Such a vision or solution ('how to achieve goals', following Anderson and Carlos, 1976) also represents authority in the above-mentioned sense. It represents authority if it (i) concerns the relevant whole, (ii) puts something into perspective and (iii) is recognized as such by a sufficient number of actors.

Defining boundaries is an element that needs separate attention. It is partly implicit in the definition of problems that follows from agenda-setting. Determining the boundaries is also closely linked to the question who does and who does not join in the discussion about the agenda. The same applies to the other elements. Take authority, for instance; authority is not limitless. Authority always applies vis-à-vis a more or less defined territory; outside of which apply the remarks: 'What's it to you?', 'What do you know?' Boundaries are crucial. They are also constantly subject to dispute, negotiation and renegotiation. Boundaries mark inclusion and exclusion. But again, this repeatedly concerns exclusion and/or inclusion vis-à-vis something. This applies perhaps pre-eminently to the presented solution, which must be defined as superior in comparison to other trajectories, by way of a clearly defined boundary.

Agenda-setting, authority, resources, solutions, boundaries – these are all concepts that mutually define each another. Without the other terms, each concept on its own becomes an isolated and therefore meaningless notion. Collectively, these concepts refer to an actor-network (or a socio-technical network). Within this network, agendas, authority, solutions and so on follow naturally from one another. It is the essence of a network to produce a high degree of congruence.

A typical feature of the period of modernization is the emergence of complex constellations characterized by a multitude of networks that operate alongside one another, but which also partly overlap and partly compete with one another. In other words, there are *multiple structures*, and therefore variation and selection; hence, the ordering of a highly heterogeneous world.

Why? I will confine myself to one or two observations. Compared to the traditional world, agenda-*setting* became increasingly desacralized in the modern world. Priests, elders and nobles lost their power and control. People themselves were increasingly looking for solutions and answers. New forms of authority were acquired in the process and, again, became institutionalized.

Another example concerns the value of what is tried and true (the Jean Auel formula). Confronted with the decreasing importance of local authority and with the emergence of new, at first seemingly imperative parameters such as markets and technology, many farmers redefined their solutions in their own, often original, ways, hence giving rise to a whole gamut of farming styles. Of necessity, they crossed the boundaries of the tested and true and developed various, contrasting, sometimes complementary, sometimes competitive solutions, each of which represented a search.

The preconditions for such a development are also clear, at least in retrospect. Again, I confine myself to a few considerations. The first concerns the degree of institutional clustering. Or rather, its absence. Far-reaching institutional clustering can, as I argued above, nip many, if not all, innovations in the bud. In this context, it is telling that calls for 'protected spaces' are heard (Kemp et al, 1997; Kemp et al, 1998; Van Lente and Rip, 1998) in the very situations that are characterized by a high degree of institutional clustering. A second essential precondition concerns the necessary self-confidence. A third concerns the required design capacity, the art of creating new solutions and new development opportunities.

Actors, Projects, Co-production, Convergence and Distantiation

In the beautifully written introduction to *Organizing Modernity*, John Law describes projects as 'self-reflexive strategies for patterning the network of the social' (1994, p20), a description which captures the meanings of agency, virtual networks and their interrelations. At the same time, Law describes these strategies as modes of ordering, as the mechanisms that shape social life. This underlines that these modes of ordering do indeed work via the future, precisely because they are the expression of the reflexive strategies that constitute networks.

No direct one-to-one relation can be assumed between a mode of ordering and the practices that emerge from it.[30] The decisive element is the interaction between various modes of ordering.[31]

As indicated previously (in part as a result of Figure 8.4), the presence, interaction, synergy and tensions between various, sometimes even conflicting, modes of ordering must always be anticipated in the construction of a network. The outcome of this process is, in principle, indefinable. Strategies and projects will be adjusted – that is, unfolded in a particular way – to enable interlocking of and/or distantiation from other projects, strategies and modes of ordering. Considered thus, a network ('for patterning the social') is, above all, a particular set of modes of ordering linked together or defined vis-à-vis one another.[32]

In the process of constituting and developing such networks as a set of interrelated projects, interfaces are crucial. This concept, largely developed by my colleague Long, refers in essence to discontinuities, to issues and social relations that do not necessarily follow on from one another (Long, 1989; Long and Long, 1992).

The idea grew from another concept: linkages. A different research group (from Leiden University) developed this concept to explain how various issues and relations are constantly forged together by linkages, originating from their (supposedly) underlying structural patterns. The Wageningen reaction to this, most imaginatively expressed by Long, was that it was not so much the unproblematic linkages that should be the focus of attention, but rather the incapability to combine various issues and relations (i.e. the problematic linkages).

Thus, interface analysis was born – that is, the study of both discontinuities and the, above all, unpredictable and often difficult to grasp ways in which translations sometimes emerge at the level of interface – translations that, in turn, produce a highly ordering effect, even though it is not chosen by anybody as such.

> *Interface studies are essentially concerned with the analysis of discontinuities in social life. Such discontinuities are characterised by discrepancies in values, interests, knowledge and power. Interfaces typically occur at points where different, and often conflicting, 'life-worlds' or social fields intersect. More concretely, they characterise social situations … wherein the interactions between actors become oriented around the problem of devising ways of 'bridging', accommodating to, or struggling against each others' different social and cognitive worlds* (Long, 1989, p232).

The development of a project implies risks, which are largely related to the question of whether the required connections with other projects can be established. Considerable risks exist on and around the interfaces. Heavy investments are often required in the creation of concrete agreements. The withdrawal of one actor can imply a major disappointment. Realization of possibilities that have thus far not been taken advantage of is risky, for the individual actors involved in the construction of a new network, and for all of those involved as a whole.

Risks are perceived in various ways. If the realization of a certain project presupposes a considerable input of external capital – that is, the association with an external financier – this introduces a perspective in which the relation between opportunities and risks are decisively different from when this does not apply. External funding implies a particular way of valuing invested capital – that is, as an increase in the value of invested capital. This entails particular criteria: it forces the actors involved to develop their project in a particular way – that is, to extend certain possibilities, to curtail or exclude other possibilities, to enter into certain coalitions, to rule out others. Such 'coercion' will apply less if one can use one's own resources and if other forms of valuation can be chosen.

Financial capital[33] wields a highly conservative influence: it 'forces' the development and utilization of new possibilities into the mainstream of established projects and their related interests and visions. It corkscrews new plans towards dominant constellations and towards their associated certainties. These constellations seem to offer *trust*, the (supposed) certainty that there is no, or a lesser degree of, risk. Related interests are reproduced via the chain of risk avoidance, the search for certainty and dominant visions. Capital, in the Marxist sense, represents power and dominance, but not for intrinsic reasons. Capital retains its dominance because it is repeatedly used as a guiding compass in the process of project development.

There are, of course, other ways to develop and realize a project:

1. by using resources that do not need to be used as capital in the narrow sense of financial capital;
2. by using other calculi, with a broader range of values;
3. by structuring the development process differently (for example, step by step as opposed to all at once).

Agency is crucial in the development and realization of projects. In this context, I understand agency to be the capability to create the required interrelations with other projects. In other words, the capability to recognize, to utilize, to bridge or to reconceptualize discontinuities as essential demarcations. Insight into the interaction between intended plans, the interaction between presupposed positions, actions, reactions, outcomes, benefits, costs and their allocation is decisive in this.

Therefore, agency is the capability to create *virtual congruence*:[34] congruence that does not yet exist (or is not yet necessary), but which is decisive for the future of the projects under discussion. To create future congruence, coordination in the here and now becomes decisive: the required congruence is achieved by way of coordinating various development projects vis-à-vis each other. Failure to do so results in incongruence. Fragility is therefore a term that should be part of any analysis of social developments, because the effective construction of congruence and coherence is probably the exception in real life. In view of the many possible discontinuities, risks and incapabilities, failure seems to be more likely than success. This applies more strongly when it concerns innovations and the more so when it concerns deviations from the institutionalized patterns and regularities. The search for and extension of such 'deviations', however necessary when established patterns go wrong, is and remains particularly fragile.

An Example

In the autumn of 1998 the *Friese Ecologische Zuivelfabriek* (FEZ, Frisian Organic Dairy Products) was opened in Drachten. However, the real, the essential, innovation is not the building and inauguration of this factory, but the preceding rearrangement of projects vis-à-vis one another. Numerous projects were at issue here: those of the many organic dairy farmers (about 80 in Friesland at the time) who at the time had to have their milk processed beyond the provincial borders; furthermore there was the, shall we say, potential project of an unknown number of dairy farmers considering a changeover to organic production, but confronted by a series of questions. These questions all related to the future actions of others. They raised many uncertainties: will consumer demand grow sufficiently to support the higher supply levels and maintain higher prices? Will the cost increases related to producing organically exceed the benefits? Will the profits of the organic circuit become increasingly extracted by those controlling large-scale processing (that is, the owners of the new organic dairy factory)? Is it possible, if the intended project (the changeover to organic dairy production) appears set to fail, to fall back on the existing patterns (specifically: will it be possible to rejoin Friesland Coberco Dairy Foods, the largest and, by now, sole processor of milk in the north of the country?).

The initiators (who intended to build the FEZ) also had an almost infinite series of questions, which again were related to the future actions of others. Will sufficient dairy farmers want to change over and supply the new plant? If not, there will be underproduction and losses.

If the new project to establish processing and marketing units is successful, will the big brothers (the established dairy companies) subsequently decide to invest in this new area and attempt to outcompete the FEZ? Will consumers accept the scale increase of production, processing and marketing? And is it possible to realize a reduction in the consumer price through this scale increase (and the subsequent cut in, for example, logistical costs), without having to lower the farm gate price? Alongside consumers, who buy organic products for reasons of principle, will new groups decide to purchase because of the lower price (although still higher than the price of non-organic products)? To what extent will supermarket chains cooperate? Will financiers (banks) want to cooperate in the realization of the intended project? And to what extent can new government projects, such as green funding, be used in order to win the financiers over and/or to present better conditions?

It is clear that – even though we have only discussed some of the actors involved – their projects, and the many questions and uncertainties surrounding those projects, cover an almost infinite sea of possibilities. If each actor has at their disposal X alternatives of future action and there are N actors in question, X is raised to the nth power. In the case of eight actors (organic dairy farmers, farmers considering a changeover, the initiators of the FEZ, the conventional dairy companies, consumers, banks, supermarket chains, government) who each have, say, five alternatives for action at their disposal, there are almost 400,000 (390,625 to be exact) possible final constellations, the majority of which will be characterized by a sometimes high degree of incongruity.

Only in a limited number of cases will there be congruence, a 'working whole' (Roep, 2000) functioning properly and, indeed, generating the expected results and distributing them in such a way that there will be continuity.

To be able to operate in this sea of uncertainty (that is, to be able to actually realize innovations), it is essential for all relevant actors to choose or develop their alternatives for action in such a way (to have their projects evolve in such a way) that real interweaving and mutual reinforcement emerges. Projects should be integrated into the working whole; a working whole that does not yet exist, but which (still) needs to be realized. In other words, it concerns an (increasingly concrete) expectation that will structure the doings of the actors involved (as expressed by the slightly abject, but still frequently used phrase that 'they have to be of one mind').

In the creation of this expectation (this interpretation of a new working whole), an essential role is played by agenda-setting, integration, boundary definition (who will be involved?, in which ways?, how to keep negative and disintegrating forces at a distance?) and scale (what level of cooperation and how many participants are needed to define the 'working whole'?). The more convincing answers, solutions and prospects are generated with respect to integration, definition, and scale the more convincing the presented course through the sea of uncertainty will become (precisely because the uncertainties and their associated risks become eliminated step by step).

In fact, the thus presented degree of complexity returns at least twice. For even though it is possible to conciliate a working whole, it will actually have to be constructed subsequently. The seemingly real possibility will have to be realized. This is only possible if the participants effectively devote themselves to its realization. If they do not – if in the interim they withdraw or they adjust their projects in a non-congruent way – it can still go completely wrong. Thus, the trouble experienced by other participants will appear in vain: it will reveal itself as a cost with no return. Hence, fragility needs to be considered.

Furthermore, a solution (whichever one) will have to contain a sufficient degree of acceptability: there will have to be an acceptable balance between advantages and disadvantages, between benefits and costs. If it appears that free riders can rake in an unequal share of the benefits without sharing the costs of the whole, this may provoke extensive desertion. The same will occur if some partners have to carry a more than equal share of the costs.

The uncertainties in question are largely related to the expectations of the actors involved with regard to the future actions of other, similarly involved, actors. What will the others do? And to what extent will I be able to influence their projects? Or rather, to what extent can the developments of my project and that of the others be integrated so as to create co-evolution? How can fragility be reduced? How can the required acceptability be achieved?

These are weighty questions, especially if one realises that neither hierarchy nor the autonomous development of market relations[35] provide an obvious answer and/or a smoothly functioning mechanism for the construction of such an answer.

Why and how was co-evolution constructed in this particular case? I will only mention a few elements here. A first important element was the increasing pressure from supermarket chains on the large dairy companies to offer a range of organic products alongside their conventional ranges. Given the hesitation of these dairy companies to independently start a separate line for processing of organic milk, a coalition between the initiators of the FEZ and the large dairies became increasingly obvious. The latter eventually participated in 33 per cent of the financing of the FEZ; more importantly, they also declared that their suppliers were allowed to change over to the FEZ without having to pay withdrawal fines; furthermore, the suppliers would have the right to rejoin the companies in question within three years if FEZ's results were disappointing.

This clearly indicates a package deal: participation in the FEZ and hence being able to satisfy the desires of the supermarket chains became possible by offering good conditions to the potential suppliers. Thus, various projects became interwoven; they were combined into the indispensable connections upon which the new working whole had to be based. As a result of this package deal, which was definitely not undisputed, a number of other positive effects occurred relating to distribution and its costs. If lorries of the large companies stop at the FEZ, supermarkets could be supplied with a wide range (including organic products) from one lorry-load.

In early 1999 I had a long conversation with Henk Brouwer, initiator and current director of the FEZ. Looking back he says;

> *Yes, you do indeed set out with grave uncertainties, and you want to move towards more certainty. But of course you never achieve this… If I look back, it was mainly faith that grew in the start-up phase. Faith on both sides and also faith in one's own abilities, to the extent that you dare to take risks. You need faith, commitment of all those who will become involved in such a chain, of farmers, financiers, retailers, the whole lot. This faith will in turn give you the feedback that you're on the right track.*

Here I want to bring forward a number of elements that played an important role in the creation of this faith (and therefore in the construction of the FEZ as a new socio-technical network). I do this especially because these elements are in sharp contrast with the way in which expert systems usually operate and also because those same elements sometimes represent a somersault through past, present and future.

A first element concerns the *goals*. While expert systems usually arrive at a clear indication of objectives, to subsequently implement these via standard planning techniques (which create *en passant* the required prescriptiveness and verifiability; cf. Christis, 1985), a completely *different* approach applied to the creation of the FEZ:

> *You have to know which way you want to go, you'll have to be very clear about it, but otherwise your more concrete goal is something that emerges slowly as something that you work towards. Most important is to define the margins, to drive pickets into the ground. Those margins or boundaries are V-shaped as it were, they take you closer to where you want to be … Yes, of course it's true that you adjust your objectives along the way. I wanted much more at first, and other things too.*

In other words, the goal around which the necessary set of partners (the *virtual network*) groups itself, is not well defined. In fact, it is precisely the other way round: an at first loosely organized network is gradually working towards a set of shared objectives. Partners will drop out, new partners will join. Meanwhile, the possible goals become more and more sharply defined, hence creating faith on both sides.

Network and strategy consolidate each other to the same extent. Neither one is a function of the other. Henk Brouwer is very outspoken about this:

> *In the beginning you're swimming against the tide. I have had some problems addressed – for example, where roughly the break-even point would be. It gives you some idea, and then you can again determine where the margins are, where the pickets have to go; and thus the end goal gradually takes more shape [agenda-setting and particularly agenda-building appear as key factors here]. No, the planning approach with one well-defined goal from the start, from which you have to reason backwards – it doesn't work like that. Yes, that's the way the large organizations*

> *deal with things, but not surprisingly that's how they kill everything off. The Investment and Development Company for the Northern Netherlands [*Noordelijke Ontwikkelings Maatschappij*] wanted me to do that, but it was impossible of course. That's how they set up a dictatorship, they dictate things, they issue a diktat, but things work the other way round.*

A second important element was, so I understand from Henk Brouwer's story, the introduction of clear *rules of the game* on the basis of which the required network (however virtual at first!) could be demarcated and consolidated:

> *Farmers, processors, and the trade, and the others too, they all had to benefit from it.*

Hence, the foundation was laid for the actual interlocking of various projects, which occurred much later.

But more rules were developed:

> *Sooner or later you'll have to make it clear that it will continue, with or without the other.*

Here emerges what I pointed at previously: authority. And related to this: the moment at which involvement (of the other partners) becomes a choice, whether or not to actively contribute and devote themselves to the cause.[36]

Furthermore, there is a third element, the combination of *autonomy* and *fallback position*. The most important resources were to a large extent controlled by the initiators. Here I refer not so much to financial resources (which partly evolved from the sale of a considerable share of the quotas of their former dairy farms), but above all to immaterial resources, such as the capability to (in all likelihood) actually manage the required socio-technical network (to actually supply retailers with a high-quality and organic product, to actually have retailers commit themselves, to actually have a number of producers supply organic milk etc.).

Agency, not in an abstract but rather in a concrete sense, reveals itself here as resource par excellence. In obtaining this agency, the aforementioned start-up phase (in which a network emerged, expectations were adjusted vis-à-vis one another, faith emerged) was a *sine qua non*. Without wanting to go into detail, the availability of a fallback position ('if it had gone wrong, it wouldn't have been the end of the world') was important in the creation of this indispensable precondition.

An organic dairy factory has now been established in Drachten, despite being initially regarded by various expert systems (the 'Eindhoven' office of the Rabobank,[37] the large dairy companies[38] and the Ministry of Agriculture)[39] as unthinkable and/or unfeasible. The creation of this factory is exceptional in that it illustrates the realization of agency in a context characterized by and also controlled by expert systems that increasingly rule out such agency.

It goes without saying that all this is closely related to the question about the interrelations between various ordering principles, and to questions about who and what will create the future, which conditions will have to be met, and what its legitimacy will be.

Agriculture as Empirical Object

Agriculture as a particular empirical phenomenon presents complications, but also a certain advantage. The advantage can be described easily. The search for and creation of congruence and consistency within projects (between the natural and the social) as well as between projects, the subsequent complexity of the coordination issue, and the sometimes inclusive, at other times radical, nature of the variation and selection processes make their presence felt more in agriculture than in other areas. Why? In agriculture, there is always and everywhere an enormous number of actors. There are now about 110,000 farms in The Netherlands, involving more than 300,000 workers. Furthermore, there is an immense agribusiness: a set of enterprises supplying commodities and services to the primary sector. A further 250,000 workers are involved in this.

In contrast to various other sectors, this complex and variegated whole, this multitude of projects, cannot and does not allow itself to be managed like a command economy. Coordination is essential, particularly in and around agriculture. In addition, present, past and future fall continuously on top of each other, sometimes in the most bizarre ways. This makes contemporary agriculture such a fertile, yet difficult, empirical territory for the issues under scrutiny here.

Two issues should be clarified from the outset. They concern the relation between the words and the things, and between things.

There once was a time when it was felt that The Netherlands were 20 years behind the rest of the world – Germany acted as the most direct point of reference. Similarly, agriculture and the countryside were seen as being 20 years behind the rest of society, i.e. the city.[40] All in all, this does not do agriculture and the countryside much good. It is hard to imagine them without the stigmas of slowness and tradition, of reluctance and resistance to adopt that which has been widely accepted elsewhere for some time. Incidents, discussions, images and events that seem to support such an interpretation are not difficult to find.

What needs to be stated clearly and resolutely is that the agricultural sector is often more modern, progressive, dynamic and innovative than the rest of society. Not 40 years behind but in some ways 10, sometimes 30 years ahead. However, this applies (let me dampen the fun at once) not only in a positive sense but also in a negative one.

In the conventional view of agriculture, the countryside is seen as intrinsically traditional and conservative. While the rest of society had thrown off the shackles of the past, the modernization project only began to become defined in agriculture in the late 1950s. Backwardness rules, certainly if we realize that at the end of the 20th century things have still not been put right.

In this conventional image, the relation between the words and the things is completely amiss, persistently amiss. For, even though these are established self-evident habits, or an institutionalized view, it has to be stated that the relationship between the notions employed and the practices grasped and interpreted with these notions suffers on all sides.

Of course, there is tradition in the rich and complex agricultural history of The Netherlands. However, there is no absolute traditionalism, in the sense of conservatism and stagnation. This has been demonstrated in the diligent work of agricultural sociologists and historians. The seeds of progress slumbered in the bowels of tradition.

Certainly in the 19th and 20th centuries, a comprehensive process of modernization took place, spurred on and driven by the peasants of the time. Tradition and progress, conservatism and progressiveness do not constitute opposites. As I will stress, each needs the other. The balance between the two is essential (Terron, 1984).

The great modernization project became defined at the end of the 1950s. However, the principal issue is that, again, the word was wrong from the beginning. It is not true that agriculture only started to modernize from that moment onward. It had been modernizing for a long time. Looking back, one cannot but say that this so-called modernization project was definitely not what was expected and suggested at the time (nor later): to finish once and for all with tradition, to finish once and for all with the rural as consistently backward.

The agricultural modernization project of 1950–1990 was one of the first great megaprojects realized in The Netherlands.[41] It was not an adjustment of a past that was moving too slowly, it was a universal operation in which the future was made to dominate the past and the present. All in all, the so-called modernization project in agriculture was (and is) an 'undercover megaproject'. It was not the beginning of modernization in agriculture, it was about the forced implementation of another modernization path than the path or trajectory followed up to then. However, the particularities of this modernization path remained undiscussed, for it seemed to be about modernization *tout court*.

The gradually manifesting chaos of the undercover megaproject should be thought through and included in the planning and assessment of the megaprojects that are now (40 years later) being defined in society at large. There is a case for the thesis that expert systems and macroprojects are almost inevitable in contemporary society – at least with regard to certain issues.[42] What is fascinating about agricultural modernization as a macroproject, however, is that it was unnecessary, certainly from a comparative perspective. We would have had a different kind of agriculture – probably of a better kind, maybe of a worse kind. However, it is impossible to maintain that agriculture and the countryside would have vanished without the great modernization project. This knowledge prompts a critical examination of the ways in which expert systems operate and intervene in the organization of time, space and social practices.

So much for the relationship between the words and the things, the social constellations and terms with which we interpret and understand them. As I stated previously, the social sciences try to understand every constellation using the vocabulary and the regularities of the previous constellation. This applies a fortiori to agriculture. As if by natural law, the things and the essentials of the periods in question are invariably interpreted and understood wrongly.

The next issue is the relationships between things. What is fascinating, but also confusing, about the world of agriculture is that there are no separations between periods and phases. Even though there are noticeable shifts in emphasis, overlap and mutual influence predominate rather than clear boundaries. In the traditional phase or constellation (see Figure 8.1a) agriculture was already modernizing rapidly. And during the decades in which the process of modernizing had become dominant (as represented in Figure 8.1b) a megaproject, confusingly named 'modernization project' was developed and implemented. This was in fact an expression of the 'postmodern' operation of expert systems *avant la lettre* (see Figure 8.1c). More accurately, the moment when the past finally seemed to lose its straitjacket, two new, unequal but interconnected, developments emerged.

On the one hand, modernity, which had already been hidden in the bowels of traditionalism, made its entry. Building upon experiences, practices and resources, which had all been handed down through history, multiple developments were initiated resulting in a variegated morphology, in a wide range of farming styles, each one equipped with a particular future project, an attempt to develop its own practice (that is, its own farm and set of relations into which it is woven) corresponding most closely to its own wishes, insights, interests, capabilities and limitations. Even though the term would be used only much later in the social sciences, one could say that agency increasingly flourished from this moment onwards. More or less at the same time, a countermovement was defined, for an expert system was created through which farm development was represented as a uniform process.

It follows clearly from the previous explanation that the phases I described above cannot be regarded as consecutive, let alone as well-defined periods. They are ordering principles, ways of relating past, present and future in and through social practices. Analytically, one can attempt to define certain basic patterns vis-à-vis each other; empirically, however, one will always encounter different and mutually conflicting principles, sometimes dominated by the one, sometimes by the other.

Recent agrarian history is usually narrated in terms of necessity and inevitability. The development of agriculture is, to coin a phrase, structurally determined. Agricultural development has taken place in a particular way; it could not have happened differently. The development that took place over the past decades informs us about underlying forces. These forces will also, and probably more than ever before, determine the panorama of the agriculture of the future.

The structuring moment is located in various 'bodies': in the coercive forces recognizable in the market sphere; in the ongoing technological development; in the complete modernization of our societies, which leaves neither the agricultural sector nor the countryside unaffected; and/or in the sphere of politics. The latter body is usually understood in terms of reflex, in terms of an intermediary between the underlying economic, technological and cultural changes.

In this narrative style, the future of agriculture emerges as a story that 'can be told in advance', as a story that is, as it were, the inevitable outcome of a script contained within the major structuring forces – forces that applied to the past and that will also determine the future.

English colleagues sometimes characterize this by the fine expression 'the race to the bottom'. Agricultural development acts in this script as a process that occurs inevitably via a combination of scale enlargement and rural exodus: less and less farmers, while the surviving farms become larger and larger. Similarly, a continuous industrialization of the interaction with the living world (of 'co-production') is therefore inevitable. One glimpse of the 'bottom' is provided by the frequently produced scenario studies, which speak of a Europe in which 75–80 per cent of rural areas have become superfluous to food production. Similar figures apply to the farming population (WRR, 1992). In other scenario studies, with regard to the Dutch dairy industry, farms are mentioned that carry 1000 cows (LEI/SC, 1996). This would imply only one and a half farms surviving in every rural municipality in The Netherlands.

The 'virtual farmer' acts as the pivot of this script, or rather of all these foresight studies. He (she is hardly mentioned) orients the organization and development of his farm to the laws of market and technology. These 'laws', which are constantly made explicit by the expert system, allow no other course of action than the race to the bottom.

In this book, I attempt to develop a different narrative, a different view. I will demonstrate that there is no structural development, no inevitable race to the bottom. Nor is there a 'virtual farmer', as posited by the knowledge system – and where the sorcerer's apprentice does succeed there is the devil and all to pay.

In other words, this book is an attempt to narrate the story of farmers, agriculture and the countryside in a different way than is by now customary. This conventional story is largely spanned by a number of axioms, by, in other words, a number of institutionalized cognitive models. They concern, inter alia, the farmer as agricultural entrepreneur and the behaviour that he (or she) should therefore display. They also concern the processes that are supposed to characterize the sector as a whole: structural development, rural exodus and the dynamizing role of the agricultural expert system. Furthermore, there are axioms concerning the real nature of farming. Above all there are a number of deeply rooted and widely shared ideas about the future of agriculture. Collectively, these axioms span a worldview (one could almost say a 'paradigm') that I will characterize here by the metaphor of the 'virtual farmer'.[43] This worldview is deceptively consistent. The concepts within it keep presupposing and (re-)confirming each other. To support the logic, the inherent truth, of one axiom it suffices to refer simply to one, or a few, of the other axioms. However, on the whole this is not even necessary. Axioms are self-evident because:

1 they are shared by nearly everyone;[44] that is,
2 they are hardly ever disputed; and
3 neither are they interrupted by a 'stubborn empirical reality', precisely because the same axioms constitute the frame for the perception and the ordering of this reality; hence

4 they span a 'universe of the undisputed': a universe of things that are the way they are because they can only be the way they are.

All this is emphasized by those who do dispute this universe: sooner or later they are exposed as *charlatans*.[45]

However high the theoretical and communicative consistencies, the problem is that this set of axioms no longer corresponds to reality. This need not be a problem if it were not that, first, policy making, implementation and evaluation are consistently informed from the point of view of the virtual farmer, and, second, the same image is a heavy burden on the urgent search for new alternatives for an agriculture that is partly deadlocked within these axioms.

The axioms share above all the common feature that they specify the agriculture of the future. They tell a story about the direction in which agriculture should move. That story is not told, however, in terms of opportunities inherent in the current reality (see Figure 8.1b). It concerns one necessary and inevitable future (Figure 8.1c). This may seem unlikely – the point is, however, that this one future is supported by a series of iron laws contained in the past and the present. The axioms refer to two aspects: they define history thus far as the inevitable unfolding of structural patterns, after which the future is represented as the perfecting of such a process of unfolding.

The cognitive monopoly of the expert system is crucial here. There is only one actor, only one institution, capable of knowing the patterns and hence the future: the expert system in and around agriculture. An expert system that is increasingly forged into a unity, also in organizational terms.

Somos lo que vamos a ser, we are on our way to the future. Future-oriented acting makes us what we are, especially because so many different options, roads, interests and identities are at issue in working towards the future. In the agricultural sector (but probably also elsewhere), however, the future has increasingly been parcelled out, completed and allocated beforehand by the expert systems, which specialise in this activity. And the more the expert systems appropriate the future, the firmer their hold on the 'existence' of those involved, in this case, inter alia, Dutch farmers. All their actions are increasingly conditioned and ordered by the future, which is monopolized by expert systems. Hence, the former are governed by the latter via the future.

This book is a critique of the expert system, of the semi-coherent whole constituted by the Ministry of Agriculture, Nature Management and Fisheries (LNV, *ministerie van Landbouw, Natuurbeheer en Visserij*), Wageningen University, *Dienst Landbouwkundig Onderzoek* (DLO, Agricultural Research Institute) and other research institutes, parts of the Ministry of Housing, Spatial Planning and the Environment (VROM, *ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer*), *Dienst Landbouwvoorlichting* (DLV, Agricultural Advisory Service, now privatised as *DLV Adviesgroep NV*), parts of the provincial authorities – in short, by the complex set that interacts with the agricultural sector on the basis of real or assumed knowledge.

I am part of the expert system, in a somewhat contradictory way. Pleasure, curiosity and passion connect me to this larger whole. Yet at the same time I often experience disbelief, rage and disturbance at its shortcomings. In any event, I feel no false obligation to be loyally silent. It is rather my right and my duty (in that respect, I take my job in an old-fashioned way) to criticize when necessary, especially when others are hardly, or not at all, able to do so.

However, let there be no misunderstanding. For – even if I am aware of the conventional classification systems on the shop floor, which divide the components of the expert systems into categories such as 'twits', 'eccentrics', 'dimwits', 'barons' and 'simpletons' (a complex world!) – I argue strongly that we generally deal with very capable and driven people. The failure of the expert system does not concern the qualities of the people involved. What is fundamentally wrong is the way in which we organize and apply knowledge. That is all this book is about. Nothing else.

Storylines

The theme has been clearly defined by now. Five distinctively different storylines can be identified within the described framework. The storylines interweave and interconnect in places. In other places I attempt to develop first this, then another, storyline independently.

The first storyline concerns agriculture as a complex practice – as a carefully coordinated unit comprising (i) the mobilization of resources, (ii) the conversion of resources into end products and (iii) the sale of these end products.

The mobilization of resources is discussed in Chapter 2 in particular. There I point out how, via a lengthy and complex emancipation process, the mobilization of resources (land, capital, labour, knowledge, water, tools etc.) is actively withdrawn from the influence of markets. This distantiation from markets at the input side of the farm provided the basis for the success of Dutch agriculture. Creating a certain distance between farm and markets is one of the hidden ingredients explaining the success of Dutch agriculture. It is also one of the ingredients that is systematically ignored in the currently predominant description of the virtual farmer. Farmers act as *Homo economicus* within the image produced by the contemporary agricultural knowledge network, as entrepreneurs integrating their farm fully into markets and therefore following and implementing the logic of the market: as puppets on a string.

Dutch farmers are, I will argue in this book, not so much the entrepreneurs they should be according to the agricultural expert system, but peasants: producers who, for the sake of their own survival, actively withdraw the processes of farm management and farm development from the logic of markets that seem to ignore their survival.

'We have never been modern', according to Latour in a well-known essay (1994). In its footsteps one could claim: 'Dutch farmers have never been entrepreneurs' (which in fact has already been raised by Constandse in 1964). They are peasants, and precisely because they are peasants they have proved to be so successful through the ages. The fact that this is also extremely topical and relevant nowadays is discussed in Chapter 5.

The transformation or conversion of resources into end products is discussed at length in Chapter 4. This transformation (for example from grass and cows into milk and meat) is conceptualized in the agricultural expert system as regulated by production functions: a fixed relationship between inputs (grass and cows) and outputs (milk and meat). It is assumed that new, more productive and/or more sustainable production functions can only be created after technological breakthroughs.

In contrast to this thesis, I want to develop another image. Indeed, there are regularities and patterns of coherence. Unmistakably, the relation between inputs and outputs (the I/O relation) displays a certain range and contains a certain, as yet uncrossable, frontier function (the most efficient I/O relation) in certain, temporally and spatially restricted situations. But what is important here is that these patterns or regularities are a product, a result of the labour process in agriculture. Furthermore, I regard the labour process as locus of co-production, of the continuous encounter between, and mutual transformation of, the social and the natural. Precisely because the results of this co-production are rooted in, and arise from, the labour process, it will always involve extremely variable I/O relations. New production functions are constantly created in and through the process of farm labour: new patterns of coherence that correspond closely with farmers' own interests, perspectives, insights and knowledge.

In previous studies of farming styles, researchers concentrated initially on the above-mentioned dimensions: the conversion and mobilization of resources. This initially limited approach was later broadened, thanks to the work of Kerkhove (1994), Ventura and Van der Meulen (1994), De Rooij et al (1995), Wiskerke (1997), Van der Meulen (1999a, 1999b) and Roep (2000). The studies identified the sale of end products and, hence, the specific circuits connecting production and consumption as ordering principles, as essential types of interlocking, and therefore as crucial parts of socio-technical networks. I will return to these new insights in Chapter 9, where new development opportunities for Dutch agriculture will be discussed.

What is important in this first storyline is that the interconnected domains of mobilization, conversion and sale contain considerable variability – each separately, but above all collectively. They are malleable, flexible, changeable. The resulting variability cannot be understood as a 'fixed' range: it is constantly enlarged in the practice of farming – that is, by farmers' innovative capacity.

Similarly, the potential variability is constantly restricted, if not reduced. If two keywords describe agricultural history and its development of production capacity, they are variation and selection. On the one hand, there is a constant search for new patterns, and for new combinations, to further increase the already available variation. On the other hand, some patterns, and some combinations, demonstrate that they are more successful than others, while others prove unsuitable in the light of changing social and ecological conditions. Thus selection appears, while the provisional end result of the selection is the starting point for the search for and creation of new variation.

Farming is like 'a dance through time': time and again variation and selection result in new socio-technical networks, new types and connections. While these new expressions emerge, others degrade and disappear – sometimes stealthily, almost unnoticed, at other times abruptly.

This brings us to the second storyline. It concerns the heterogeneity of farming as the (temporally and spatially confined) expression of this 'dance through time'. In Chapter 3 of this book, I will discuss in detail the farming styles that can be distinguished in contemporary Frisian dairy farming. I will try in particular to describe these styles as projects, as 'self-reflective strategies for patterning the network of the social' and, hence, as part of a more comprehensive socio-technical network.

The remainder of the book builds upon this, particularly Chapters 6 and 7, which discuss selection, and Chapter 9 in which variation is discussed. More precisely, in Chapters 6 and 7, I analyse the interaction between the development opportunities inherent in various farming styles and the dominant agro-political project – that is, the process of modernizing agriculture – while the interaction with a new agro-political project, in which rural development has a central role, is analysed in Chapter 9. Chapter 8 forms a link: there the central theme is the extensive erosion of trust, the essential ingredient in the functioning of expert systems.

The third storyline can be summarized as a systematic critique of various forms of determinism: of technological determinism (in Chapter 4, inter alia, where the doctrine of production functions is discussed); of economic determinism (in Chapter 5); but especially of what is called structural determinism, which has overrun the social sciences (including rural sociology). Chapters 6 and 7, which discuss modernization as 'the unfolding of structural patterns and relations', can be understood as a critique of structural determinism. There the agricultural knowledge system, the expert system that represents, propagates and realizes this structuralist notion like no other, is discussed at length.

The fourth storyline is the obvious counterpart of the third: it entails a search for a more adequate concept of structure. I have already commented on it in this introductory chapter. In this book, I will test the concepts and notions raised in this chapter, to arrive at a conclusion in the final chapter (Chapter 10). I will also summarize the critique of the contemporary expert system in Chapter 10. Chapter 9 forms an important prelude to this, which brings us to the fifth and final storyline. Chapter 9 concerns new development opportunities that reach beyond the current misery. In the discussion of these opportunities, I use 'rural development' as the connecting concept. Chapter 9, the 'battle for the future', is also concerned with the social and political struggle that was waged in the 1990s over the realization of new development opportunities.

Notes

1 Incidentally, the full text runs as follows: '*vivir es constantemente decidir lo que vamos a ser*'. The author states further: '*nuestra vida es ante todo toparse con el futuro … la vida es una actividad que se ejecuta hacia adelante, y el presente o el pasado se descubre después, en relación con ese futuro. La vida es futurición, es lo que aun no es*' ('life is above all dealing with the future … life is a progressive activity, and the present or the past is discovered with hindsight, in relation to the future. Life consists of making futures; it is what it is becoming'; Ortega y Gasset, 1995, p228). For a further comment, see Remmers, 1998, chap. 7, esp. pp313–317.

2 I am acutely aware that it is easier to speak about the great period of modernization than it is to define the period. Two issues are clear. First, the era of modernization was constructed only gradually in civil society as a whole. The rise of capitalism – initially in the Italian city states, later in The Netherlands – and the subsequent civil revolution in France, the Enlightenment, and the industrialization that started in England all represent many stages in this protracted process. Second, it is clear that the same process of modernization occurred in agriculture much later than in the urban sphere of influence, although it is not clear exactly where and when to situate the turning point. The work of Hofstee is a case in point. In his 'early' work Hofstee (1946, 1985) located modernization (the turning point from a traditional to a modern-dynamic cultural pattern) in the first half of the 19th century. Furthermore, he sometimes refers to the early Middle Ages and to the periphery of the then feudal systems as the cradle of modernization. In his 'later' work (see, for example, Hofstee, 1953) the post-war period of the 20th century acts as the turning point. The identification of the turning point is, as is well known, highly controversial. Historians such as Van Zanden (1985) and particularly Bieleman (1987) have indicated that in the olden days agriculture already showed remarkably 'modern' features. Be that as it may, it is striking in this controversy that no one disputes the difference between 'traditional' and 'modern'. The big question is where, and particularly when, to situate the beginning of certain phases.

3 Again, it is not my intention to look for clear boundaries in time, hence the use of the vague description in the main text. Incidentally, it is remarkable that this 'next phase' started earlier in agriculture, so it seems, than in the rest of society. See in addition Chapter 6, where the functioning of the expert system in agriculture is described.

4 As I will demonstrate below, we should perhaps say: in that which specifies our future. The contemporary expert systems are more than just a collection of scientists, specialists and experts. They are also the paramount prisoners of the axioms that regulate knowledge production.

5 James Scott relates the phenomenon of mega- or macroprojects largely to the functioning of the contemporary state. Thus, he interprets megaprojects as 'state simplifications'. These simplifications (as such inherent in the functioning of bureaucracies) 'do not successfully represent the actual activity of the society they depict, nor are they intended to; they represent only that slice of it that interests the official observer… [They are simplifications] that, when allied with state power, will enable much of the reality they depict to be remade' (1998, p3). Scott points out that the development of megaprojects ('the tragic episodes of state-initiated social engineering') arises from a combination of four elements: the 'administrative ordering of nature and society', a 'high-modernist ideology', an authoritative state ('willing and able to use the full weight of its coercive power to bring the high-modernist designs into being'), and finally 'a prostrate civil society that lacks the capacity to resist these plans' (1998, pp4–5). Indeed, those seem to be the required and necessary conditions with respect to the cases Scott analyses. However, if we introduce the modernization of agriculture into the analysis, these conditions appear insufficient. Agricultural modernization as a megaproject takes place (just like various other contemporary macroprojects) under *democratic* conditions, which refers indirectly to the considerable influence obtained by and assigned to the expert systems.

6 This has been described at length in general terms by Callon, 1986; Bijker and Law, 1992; Latour, 1994; Lowe et al, 1995.

7 The communication between farmers from various regions is a shining example of this. The 'other' was not taken note of in order to imitate but rather to understand better and, if possible, to strengthen what was one's own. If parts were adopted from elsewhere, its structure would typically be 'one's own' – that is, that which was constructed and expanded thus far, the frame from which to assess what could possibly be adopted and how it could be fitted in. (For a further analysis, see Van der Ploeg, 1987, esp. pp35–42.) It is remarkable that the 'grammar' of comparison and adoption has radically changed since then (Cristovão et al, 1994). At present, there is a clear hierarchy of 'most developed' agricultural systems and of more or less 'underdeveloped' agricultural systems. The technologies of the former now hold as the normative frame around which the agricultural practices of the latter have to be reorganized. 'Areas lagging behind in development', the term frequently used within the EU, is a striking expression of this.

8 See Long and Van der Ploeg, 1994, pp80–81.

9 This term is used to indicate the opposite of 'interlocking'. Distantiation represents creating a distance, creating room for manoeuvre or autonomy.

10 Robinson Crusoe's project, to mention probably the worlds' most famous castaway, could only succeed with the presence of the stranded ship – resources! – and with the arrival of Friday.

11 Trust emerges as one of the important mediums to cement postmodern societies together, and as a vehicle to implement developments. Trust is (in contrast to faith and confidence) highly depersonalized. It is institutionalized faith in a system and its artefacts and procedures. Trust implies that carrying out certain actions will lead to a future situation specified beforehand. If the latter situation is the objective and if the actions to be carried out are the means, trust integrates the two. If I want to cross a busy and dangerous road, pressing the button at the pedestrian crossing and waiting for the lights to change to green are the means by which to safely reach the other side (the objective; Giddens, 1990). As a pedestrian, I do not have to know the different drivers (or look deep into their eyes). I trust not so much the drivers as subjects but the 'system'. I assume that the other participants (the drivers) do the same. The knowledge that everyone acts on the basis of the system generates trust, just as the functioning of the system presupposes trust. The same example makes clear that a simultaneous coordination of various actions is necessary to realize trust. Drivers will have to stop when the lights change to red. If they want to meet their objective (let us at least hope that this consists partly of avoiding accidents), acting on the system of traffic rules (stop at red, go at green) is a necessary means for them. Trust connects everything. Without trust the system (the set of traffic lights and rules) will not work at all.

12 This trust in systems includes primarily 'the faith that a role is interpreted according to the norms, *more or less independent of the person performing the role*' (Galjart, 1998, p13, my emphasis). Galjart contrasts this trust in systems with what he calls 'particularistic trust': 'the expectation that *someone else* will cause us harm in a transaction or a relationship' (Galjart, 1998, p12). In his discussion, Galjart considers the crucial importance of trust for development.

13 If collective memory is the subject in traditional societies, just like agency in the era of modernization, the expert system is the most important subject under postmodern relations.

14 But it is possible in the long term, see Groen et al, 1993.

15 For a theoretical explanation, see Wiskerke, 1997.

16 It is no coincidence that I refer here to Harris. From his pen comes one of the most eloquent critiques of the approach that we have tried to develop in Wageningen. In the proceedings of the 50th anniversary congress of Wageningen sociology (where Harris unfolded his critique), Long and Van der Ploeg discuss the critique at length.

17 What remains intact is that one can of course use a conceptual framework in which 'external structure' acts as a causal complex. Thus emerge the so-called structuralist theories. The bankruptcy of such approaches has been amply exposed, by Long (1985) in particular.

18 The same applies to Booth as to Harris. From his pen comes an inspiring critique, a heartfelt search for the possible weak points in the Wageningen approach. Just as in Harris' case, Booth's observations revolve particularly around the question whether an actor-oriented approach excludes the concept of coercion (whatever its nature or form). See Booth, 1994.

19 Of course, the relations at issue here (the relations among various projects) can differ considerably. Some will be extremely hierarchical and coercive. This does not imply, however, that one therefore needs to fall back on structuralist approaches; I attempt to show this in Chapter 6 by means of the so-called structural development of and in Dutch agriculture (as a result of which more than half of the farmers had to abandon their farms).

20 Following the work of Giddens, it is tempting to locate such incapability in 'structure' (in its Giddensian sense). For structure is not only enabling but also constraining. It excludes certain types of action, certain manifestations of agency, while others become possible. Theoretically, this solution is hardly satisfactory – empirically, it is unmanageable, as will be shown in note 21.

21 If one looks at contemporary Dutch agriculture, the complications can be seen a mile off; because there is no other possible interpretation than that agency is ubiquitous. In any case, the presence of farms, of whatever farm, is inconceivable without the notion of agency. If, in the previous period, there had not been a determined effort to continue the farm and if one had not succeeded at this, there would be no individual farms nor a collection of farms as a whole. Every farm is evidence of the 'capability of doing things'. In agriculture (and I assume the same applies elsewhere) there are no actors walking around in a permanent comatose state. This notion of structure could be introduced as the counterpart of agency. Apart from the extremely difficult question of what should be interpreted as structure, a not very satisfactory dichotomy would emerge here. Structural relations (as 'both enabling and constraining') imply that a number of farms are doomed to vanish, while others can continue (for the time being). The notion of non-agency would apply to the first group, and agency would apply to the second group. Such a dichotomy is completely unsatisfactory. First, because it ignores, on the one hand, the fact that a number of farms are purposefully abandoned (not only intentionally, but also through the corresponding actions), and, on the other, the situation that a great many farms are continued purely as a matter of routine (see, inter alia, De Bruin, 1991, who discusses the problematic aspects of farm succession). Second, it is unsatisfactory because it is hard to understand why and how 'structurally impossible farms' (let me put it in that way for the time being, I refer especially to small or even very small farms) are sometimes continued or even guided along the cliffs of a very difficult farm transfer. If 'structure' is 'constraining' in some cases, it must be in every case; because if it does not do so in some cases (because dominated by agency), the notion of actor-structure as duality becomes very problematic. Third, I want to point to the fact that there is an impressive degree of differentiation among the 'remaining' farms; in other words, agency can result in innumerable 'things', or else various types and degrees of agency should be introduced. In short, I think that agency as an undifferentiated concept, as the opposite of structure, is very unsatisfactory.

22 In other words, Law's principle of symmetry (1994) can and must be applied here as well.

23 This does not imply that these notions, or images of the future, are *always* fluid, are always *variable* and *changeable* in empirical reality. The crux of the large macroprojects and of contemporary expert systems emerges here: they *make* the images of the future rigid and unchangeable.

24 Because on the whole, cohesion, fabric and web are very remarkable. More obvious perhaps are disintegration, the inability to coordinate, ignorance, and so on. Rather than simply taking cohesion for granted, it should be explained.

25 Van der Ploeg (1993) explains in more detail how difficult, if not improbable, it is to innovate under contemporary conditions.

26 For example *Adellijk Bloed* by Popta (1962). There is also an incipient critique in there about the expert system that was beginning to emerge in the world of livestock breeding.

27 This is the comprehensive 'modernization project' that was conceived and also materialized in Dutch agriculture from the 1960s onwards. For more detailed descriptions, see Frouws and Van

der Ploeg, 1973; Van der Ploeg, 1995, 1996. It may seem confusing at first that I present and analyse this 'modernization project' as a shining example of a 'postmodern' approach. Just as in the social sciences (see earlier in this chapter), however, it applies here that one's own projects are decorated with the colours and terms of the past. Agriculture had of course been modern for a long time before mid-20th century. See the convincing work of historians such as Bieleman, 1987. Hofstee's work (1985) is significant in this: he shows how a 'modern cultural pattern' emerged in the clay region of Groningen in early 19th century. However, as if this had never happened, the induced changes in the latter half of the 20th century are just as easily called 'modernization'. If one takes a magnifying glass and watches various processes, it would show that the term repeatedly re-emerges during and after this period. Time and again, the 'need for modernization' is mentioned: at every land consolidation, at every adjustment in arable agriculture, at every introduction of new technology, every time one has to face adverse market conditions. The power of the word is probably in the suggestion that undesired situations can be overcome once and for all in a single operation.

28 See, inter alia, Van Egmond et al, 1996; Nijhof et al, 1996; Langman et al, 1997.

29 The greatest upheaval emerges, I know this from my own administrative experience, if one allows participants other than the usual ones to join the conversation about the definition of the 'agenda'. Conversely, many examples in and around agriculture and the countryside indicate how certain voices are regrettably turned into a predominant, if not the only possible, routine.

30 In other words, one should avoided equating the eventual ordering, or its effects, with the initial mode of ordering/strategy as such. In those cases where Law speaks of 'imputation', such a danger becomes far from imaginary. What occurs as 'practice', as state of affairs, as material *effect*, at moment T and in place P will never be the unilinear effects of one mode of ordering, of one strategy, but rather of the encounter, the interaction, the mutual influencing, conditioning and often the mutual transformation of several modes of ordering, i.e. several strategies – of several interlocking projects. However, Law does indeed hint at this, for example when he discusses 'interordering effects' (1994, p22). The empirical setting within which Law conducted research (one large laboratory) was probably less encouraging to further explicate the issue touched on here.

31 In the fourth chapter of his study, Law presents four modes of ordering: enterprise, administration, vision and vocation. He stresses that they cannot be defined in terms of persons, or in terms of personal attributes. They are strategies. It is the same point with which we have often struggled in the farming styles group. For the sake of recognition, we have modes of ordering reduced to and attributed to nouns instead of verbs. In English texts, however, this is not the case. There, for example, 'the strategy of farming economically' is used consistently, rather than 'economical farmers'. In Law's analysis, those four modes of ordering are present in constantly changing combinations in the laboratory. The great difference is, of course, that agriculture is concerned with sole proprietor businesses. Therefore, there will rather be only one style, only one strategy, on family farms. (However, partnerships and corporations are interesting phenomena; in the case of several siblings, you will certainly find that one pursues one strategy, the other pursues another. Furthermore, there is of course the tension between men and women: various principles that are balanced against one another. See De Rooij et al, 1995.) Law stresses that enterprise and administration are antithetical modes of ordering. This emerges notably from various farming style analyses too. The 'economical' versus the 'ambitious' (to elaborate on one's own resources versus to mobilize as many external resources as possible; see Van der Ploeg et al, 1992). The same applies to the styles of cowmen *vs* machinemen; as well as to skill-oriented *vs* mechanical technologies (Bray, 1986) and to intensity *vs* scale (Van der Ploeg, 1987). Thus a mutual, although ever changing, influencing of modes of ordering occurs within the laboratory. Furthermore, Law shows that interlocking with projects (or modes of ordering) of clients, financiers, ministries, universities etc. is also going on. All in all, 'interactive systems' (Booth, 1994), i.e. 'interlocking projects' (Long and Van der Ploeg, 1994), become decisive.

32 In short, the 'network' cannot be understood simply as an aggregate of modes of ordering. All the more because the 'patterning of the social' (certainly in the current postmodern constellation) increasingly defines which modes of ordering, which strategies, do or do not fit. Here too the turning point, to which I referred previously, appears again.

33 All in all, financial capital represents nothing more than a particular project: to increase the initial amount of capital through participation in other projects.

34 A definition in terms of 'feasibility' is also important: What can I exercise influence over? What is beyond my power? 'Feedback' is already integral to all this: as part of the decision of what is relevant to me (and definitely in the further specification of what I could influence) I will have to take account of the world as it presents itself to me and/or of the world as it is presented to me. *Yo soy yo y mi circunstancia*, as Ortega y Gasset (1995) states in this context: 'I am myself and my situation.'

35 These are the terms suggested by neo-institutional analysis as solutions to problems such as those described here (see, inter alia, Saccomandi, 1991, 1998).

36 In fact, this continued to the extent that the building of the factory had almost been finished before the third partner, Friesland Coberco Dairy Foods, decided to participate. I think it goes without saying, therefore, that considerable risks have been taken along the entire trajectory. On the other hand, as Henk Brouwer argues, you 'need to be able to fall back on a number of side streets. If you can't turn left, you'll have to be prepared how to turn right if necessary'.

37 Even though leading thinkers of the Rabobank in Utrecht (its headquarters), such as Wijffels and Krouwel, supported the initiative wholeheartedly, the Eindhoven office (where credit applications are eventually assessed on the basis of formal criteria) reached a negative decision. It was reasoned that dairies were being closed all over Europe, and it was therefore ludicrous to think that a small dairy such as the FEZ would stand a chance of survival. Eventually, the Rabobank did become involved in the FEZ indirectly through Rabobank International.

38 Friesland Coberco Dairy Foods had attempted years before to set up a range of organic products. However, it had turned out to be a total flop. A new initiative by a 'small outsider' was initially regarded as rather painful: 'If we can't do it, nobody can.'

39 The Industry and Commerce Board was notable by its absence in this innovation. It is also typical that serious practical research on organic dairy farming by the expert system only started during 1998–1999. For that is the moment when institutionalized practical research (*in casu* Aver Heino) makes a changeover. It means that the first results will only be available in five years time, i.e. in 2003 or 2004.

40 The alleged backwardness became even the conceptual starting point of operationalizing the countryside and, therefore, of differentiating it from the city (see Van der Ploeg, 1997).

41 Of course, other large megaprojects did exist. In The Netherlands, they included the organization of water management, coastal defence and energy supply. It is well known that each of these represents so much as a state within the state.

42 After all, you cannot experiment simultaneously with Schiphol Airport in the North Sea, Schiphol in Flevoland (or in the Markerwaard), and the expansion of the existing Schiphol.

43 If there is anything in this world that can hardly be virtual, it is a farmer. Farmers stand in the mud, between their cows. Or they watch the latest version of a milk robot at the Agricultural Show. However, they watch all this knowing that milk will soon have to flow into the jars. In our 'virtualized world', farmers are probably the last junction of its stubborn opposite: it starts off on matter, on mud and cows, and it ends in matter, in milk or in seed potatoes. Hence, it is out of the question that there is or could be any detachment and evaporation of things into words and symbols and nothing else.

44 The 'old boys network', which clearly exists in the agricultural knowledge network or 'expert system', centres largely on aspects of one and the same set of axioms.

45 Recent agrarian history has a painful flip side, related to the 'conversion' of critics and innovators into 'charlatans'. Older colleagues have told me many stories about this. I leave the retelling of those stories to the first agrarian historian who dares to research a really controversial issue.

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9

Diversifying Rice-based Systems and Empowering Farmers in Bangladesh Using the Farmer Field School Approach

Marco Barzman and Sylvie Desilles

Over the past eight years, CARE-Bangladesh has been developing a set of sustainable agriculture projects to improve production in rice-based farming systems in this country. These efforts have contributed to an emergent programme to increase food security for poor and marginal farmers. The programme raises agricultural productivity by diversifying agroecosystems and optimizing yields, reducing costs of production and creating new income streams.

Although the programme is associated with a number of agricultural techniques that are readily adopted and disseminated, it strives to achieve more than the simple transfer of sustainable agriculture technologies. It follows a philosophy of adult education that emphasizes personal experience and builds up people's confidence and ability to manage their future development (Hagmann et al, 1999). The main difference between this and other agricultural development programmes has been its emphasis on knowledge and experimentation, rather than technologies and material inputs. The programme enables farmers to take initiative in experimenting with and understanding ecological processes in their fields.

These principles and methods have been developed as part of a regional programme to refine and spread Integrated Pest Management (IPM) practices within Asia, supported since 1982 by the UN Food and Agriculture Organization (FAO) (Röling and Van de Fliert, 1994). This chapter reports on experience in Bangladesh, focusing on the programme's philosophy and operation as well as its results.

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Programme Overview

The rice programme in Bangladesh has had two aims: to increase rice field productivity and to empower farmers in terms of their decision making and management capacities. The rice field is the main source of revenue for the category of small farmers targeted by the projects. Appreciating this, the programme seeks to enhance the capacity of households and communities to independently generate, access and disseminate knowledge. This is achieved through the facilitation of a team of skilled and motivated staff who are given the task of creating an effective learning environment in which farmers test a variety of sustainable agricultural practices.

The dual objective of exposing farmers to agricultural innovation and of empowering them is achieved through the creation of Farmer Field Schools (FFS) adapted from experience in other Asian countries (Kenmore, 1997). Important elements of the approach adopted by CARE-Bangladesh include the development of a broad curriculum that focuses on the entire rice cropping system and provides farmers with a 'menu of topics' to choose from, and an experimental approach in which farmers are considered researchers (Kamp and Scarborough, 1996).

The agricultural techniques in the programme have been:

- sustainable agriculture practices in rice;
- vegetable production on rice field dykes;
- fish production inside the rice field;
- production of fish fingerlings;
- tree planting on rice field dykes.

These practices increase rice-field productivity through optimized use of the natural resources available. The way in which these practices are learned is intended to result in a certain level of farmer empowerment.

An innovative, field-tested model for adult education has been developed through experience with three related projects supported by the UK's Department for International Development (DFID) and the European Commission. The programme during its initial phase (through 2000) involved around 150,000 farmers. The second phase, now started, disseminates this model to other organizations, non-governmental and governmental. It expects to reach more than 1 million farmers within the next six years. The activities of the expanded rice programme will include more emphasis on homestead gardening and vegetable growing.

Impact on Farmers

The core agricultural practices of the programme – sustainable rice production, rice–fish farming, vegetable dyke crops and trees on dykes – aim at sustainable and optimal land use, a fundamental issue in rural Bangladesh. Households with limited access to land need farming systems that generate more income and food in an efficient, reliable and sustainable manner.

Rice Production

Between 1995 and 1998, small-scale rice growers in the project areas obtained 4.7 and 3.2t/ha yields in the dry and monsoon season respectively (n = 2927).[1] Data from 1995 to 1997 show that project participants generate yields that are on average 4 per cent and 11 per cent higher than non-participants in the dry and monsoon seasons respectively (n = 1640). This was achieved mainly through changes in fertilizer and pesticide use, transplanting time, spacing, variety, and seed and seedling quality. While these increases are modest, they combine with reduced production costs to raise household incomes.

Most of the reduction in production costs is from reductions in insecticide use. In 1999, for example, the percentage of participants using insecticide on their rice at least once dropped from 86 per cent (n = 6045) in 1995 to 11 per cent (n = 7700) in the dry season, and from 76 per cent (n = 6045) to 19 per cent (n = 7700) in the monsoon. We estimate there have been savings of 486 takas per 0.11 ha plot (n = 360), which amounts to 4418 takas per hectare per year (US$92).[2]

After having obtained yield increases, farmers become willing and able to spend more on quality seed of improved or local varieties or to produce and preserve their own seed. In the highest external input use district, the percentage of participants producing their own rice seed went from 40 per cent to 83 per cent (n = 200 respondents from 21 FFS) before and after project intervention. Irrigation costs do not change, while labour costs increase slightly as farmers give more importance to certain crop management practices such as planting in rows and weeding. Overall, the costs of production for dry season rice decreased by 12 per cent, from 1.70 takas per kilo of rice produced (baseline) to 1.40 takas after two years. For monsoon rice, the per-hectare costs of production declined 30 per cent, from 1.30 takas to 0.90 takas per kilo of rice produced.[3]

For farmers, the other main consideration in rice production is reducing year-to-year yield fluctuations. Participating farmers have developed the capacity to maintain a minimum threshold of production from their rice fields while reducing their costs of production. This is essential to food security. Farmers working with the project experienced variation in yield averaging plus or minus 5 per cent, while control farmers experienced average variances in yield of 9.5 per cent.[4] The data from pairs of farmers matched by rice variety and irrigation source during seven seasons between 1996 and 1999 show that the total crop failure rate of participants was 0.3 per cent, while that of control farmers was 0.54 per cent (n = 1673 pairs of farmers).

Other Production Within the Rice Farming System

The programme is also promoting the integrated cultivation of rice, fish, dyke crops and timber trees. As rice is the staple food in Bangladesh, and also probably due to the influence of the Green Revolution, farmers invest considerable time and effort in rice while neglecting other crops. By introducing other crops within the same field and managing them through an ecological approach, farmers are able to lower their dependency on rice both as a crop and in their diet.

Throughout the year, farmers participating in the programme harvest vegetables and fish in addition to rice from their fields. They sell and consume these products in varying proportions depending on their needs and their production. The cost of production of these complementary crops produced in the rice field is minimal, and rice production remains the same or possibly increases (Barzman and Das, 2000).

Rice–Fish production

The number of farmers who produce fish in their rice fields varies from area to area depending on the local physical characteristics of the soil and the water management. By the end of 1998, 30 per cent of participating farmers (n = 11,383) were experimenting with this technique, and data taken two-and-a-half years after project intervention show that their numbers actually increase after the initial trial phase. Farmers practising this technique dig a small ditch in the corner of the field to provide shelter to fish that they introduce as fingerlings at the beginning of the season. The fish find their own food within the rice field, making their maintenance cost negligible. In the case of the higher valued native fish species, the main cost of production is the purchase of fingerlings. For common carp, on the other hand, farmers typically produce their own fingerlings.

Most of the labour in this fish production system concerns the raising of dykes and the digging of the corner ditch. The cost of water can be considered a rice production cost. Usually, family members take care of these complementary production activities. In 1997, the average cost of production of fish per rice–fish plot (n = 212) was 791 takas per year, which is equivalent to 5271 takas per hectare (US$110). All rice–fish farmers consume a part of the harvest, and most also sell the remainder.

In 1997, after production failures were excluded, the average annual potential net return per farmer was 6241 takas (n = 212), which is equivalent to 53,290 takas per hectare (US$1110).[5] Some rice–fish growers make extra income and reduce their fish production costs by producing and selling their own common carp fingerlings during the irrigated rice season. By the end of 1998, 33 per cent of participating farmers (n = 11,383) were doing this and obtained on average 609 takas per farmer (US$13) from their sales of fingerlings.

Rice and dyke crops

Vegetables can be grown on the dykes surrounding the rice field if these are raised and widened. With this technique, project participants have been producing country bean, yard-long bean and a number of squash species that are planted in small pits filled with compost. In 1998, the average potential net return from dyke crops is 1470 takas per farmer (n = 145).[6] This is equivalent to 9800 takas (US$204) per hectare of rice land over the year. The inputs required are mainly seed, organic compost for pit preparation and labour. Farmers usually just use a portion of the fertilizer that they have purchased for their rice production on their vegetable dyke crops and the organic compost is produced at no cost.

Vegetable seed is increasingly produced locally at no financial cost. One study conducted in the highest external input use district showed that the number of women participants producing their own vegetable seed went from 26 per cent to 69 per cent (n = 200 respondents from 21 FFS).[7] This helps to make the activity reasonably remunerative.

Trees on dykes

There are cultural practices, such as periodical pruning of roots and branches, which make it possible to grow trees on the dykes without affecting the rice crop. This type of pruning is not favourable to fruit trees but is perfectly appropriate to trees producing timber, cooking fuel and fodder. In December 1998, 28 per cent of project farmers (n = 19,450 farmers) were experimenting with this technique. We have observed that two years after the project had left, farmers continue to tend their trees. It is too early to evaluate the economic benefits of this technique, but we are already observing that the number of farmers planting trees on their dykes is growing and that many have initiated small-scale tree nursery businesses to supply their community with the required tree saplings.

Rice–fish–dyke crops

Since the integrated system does not decrease the yields of any one component, rice farmers who integrate fish and dyke crop production naturally compound their net returns. Already, 20 per cent of the poor and marginal farmers in the programme have adopted this combined practice.

Overall Economic Impacts

The exact economic impact of these practices on households is difficult to assess. The figures given above are based on a single 0.11ha plot whereas our participating households own about four plots averaging a total of 0.45ha on which it is impossible to say how many of the innovations are practised. Another difficulty is that households consume much of the increased production as food and donate a significant portion to relatives and neighbours, making an economic analysis nearly impossible. Even if the actual returns per household attributable to the innovations were known, we still would not know how much this would represent relative to the total income of the household and its needs. Nevertheless, the high adoption rates of the new practices make it clear that they make economic sense.

Non-economic Benefits

Measurable economic returns represent only a fraction of the benefits generated by the programme. Households and communities also benefit from improved nutrition, decreased environmental degradation and empowerment.

Nutrition

Our indicators of diet show that the project contributes significantly to improving project participants' nutrition. The project is helping to reduce over-reliance on rice by increasing vegetable and fish consumption. We find that after project intervention, the relative number of project households consuming vegetables every day doubled while those consuming vegetables only once a week decreased 12-fold. Similarly, the number of households consuming fish every day more than doubled while those consuming fish only once a week decreased nine-fold. And lastly, the amount of edible oil used by households – a good indicator of the total amount of food cooked – increased by 21 per cent on average.

Environment

It is well established that simply foregoing the use of insecticide dramatically increases the abundance of beneficial insects and will reduce farmers' and consumers' exposure to hazardous chemicals (Pingali and Gerpacio, 1997). The reduced reliance on insecticide is long lasting. Our post-project survey shows that even two-and-half years after project intervention, 77 per cent of participating farmers (n = 1200 farmers) continue to grow rice during the dry season – the high input season – without using insecticides, a long-term change up from 14 per cent before project intervention (n = 400 farmers). Another intervention with a probably significant impact on environmental sustainability is the planting of trees on dykes. Trees add a structural dimension to the rice field and provide refuge to many life forms. The data set just mentioned also shows that two-and-a-half years after phase-out, 41 per cent of FFS participants (n = 1200 farmers) still have trees growing on some of their dykes, a technique totally unknown before project intervention (Barzman and Banu, 2000).

Empowerment

Through farmer involvement, the programme hopes to strengthen the capacity of farmers and their communities to continue to innovate and to respond to future challenges without requiring project intervention (Röling and de Jong, 1998). With a better understanding of the agroecosystem and familiarity with the experimental method, farmers build up their confidence in their own knowledge, learning capacity and decision making capabilities. Field staff who work directly with farmers have no doubt that the programme does achieve this other objective. Yet this is a difficult entity to quantify.

There are signs that, as a result of project intervention, farmer innovation is taking place. Some participating farmers moved beyond the 'prototype techniques' and adapted them to suit their own needs. For example, there are farmers now experimenting with the cultivation of shrimp instead of, or together with, fish. They develop their own knowledge by studying shrimp production by larger producers, asking questions and using their neighbours and other members of the group as a source of knowledge. Whereas the programme focuses on the use of common carp – an exotic but easy-to-rear species – as the fish species of choice, many farmers are producing native species, including some that are endangered. The same is taking place in vegetable dyke crops where farmers are trying vegetable species not associated with the programme. Some farmers have taken the vegetable crops and planted them around the homestead or along roadsides and the same is true for trees originally intended for dykes.

Another indicator of empowerment is the level of organization and collective action. Some FFS, independently of project staff, have formed formal grassroots organizations. The potential impact of these organizations is great and the programme will study their development as a first step towards enhancing this process. Already, some farmer groups have taken collective action in marketing their products. Others are producing fish in large areas made up of a number of adjoining individual fields in which fish fingerlings are jointly procured and from which returns are shared among the group.

Within the FFS, farmers experiment and compare their results. They observe and monitor other farmers' fields where organizations have already installed demonstration plots. FFS participants are better able to evaluate new technical options presented by agricultural researchers or extension services. They are also more critical of proposed new technologies.

The project is also contributing to the empowerment of women, who in rural Bangladesh are confined to the household and kept away from sources of power. The project encourages women to work away from the homestead in the rice field. One survey showed that two-and-a-half years after the project's departure, 74 per cent of them were still tending vegetable dyke crops and all of them were involved in rice–fish culture (n = 1200 responses). Farmer leaders, half of whom are women, receive additional training and subsequently serve as resource people in their communities. Such women often report a newly acquired sense of worth and enhanced social status. Some of these women have been elected to the local government.

Lessons from the Rice Programme in Bangladesh

After eight years of programme implementation, some valuable lessons have emerged. The programme, which can be considered successful on several levels, has received regional and even international recognition. Some of the operational reasons for this success include the following:

- Projects sought ways to place farmers in the centre of the learning process and enabled project staff and farmers to communicate productively in spite of major soeioeconomic differences between them.
- The experiential approach, by treating the farmer as a researcher, created an environment conducive to learning and confidence building.
- Projects used sustainable agriculture techniques modified from native practices that had already been intensely tested and therefore presented minimum risks to subsistence farmers.
- Men, women and sometimes children from the same household were provided with training to ensure support from within the family.
- Working with groups on collective activities has meant a better use of resources, increased sharing of knowledge, better coordination within the community, and more acceptance of women's involvement.

The programme developed several strategies to promote wider acceptance of women working in rice fields. Staff had to be willing to learn and be flexible enough to regularly modify strategies, and a system was developed that enabled farmers to conduct their own monitoring and analysis of results.

Difficulties Facing the Programme

The success that the programme has met with respect to its objective of increasing rice field productivity has overshadowed its other objective: empowering farmers. Both farmers and staff tend to focus on the relatively rapid agronomic results obtained. And since the agroecological conditions in Bangladesh are rather homogeneous, the same agricultural practices tend to yield similar results in different locations. Because of this, projects tend to become promoters of a technological package which, even if itself sustainable, is not conducive to sustainably increasing farmers' decision making and management capacities.

The agricultural practices associated with the programme were designed as *entry points* to obtain quick results and from which projects could move on to long-term changes. But they sometimes become an end in themselves in a way that is reminiscent of the old transfer-of-technology extension model. Obviously, farmers' needs are connected to the opportunities that exist in their area in terms of land type, land tenure, irrigation, availability of agricultural inputs and resource people or organizations. Considering these factors, programme implementation, extension strategies and priority agricultural practices need to differ from area to area.

Another difficulty concerns access to services. Farmers generate knowledge through experimentation, observation and sharing, but they still need access to extension services, research organizations and markets to get the most out of their learning. There are a number of constraints that make these services inaccessible to farmers. Sometimes these are a matter of psychology. Poor and marginal farmers often lack confidence to meet 'professionals' and ask them questions. Most farmers are barely literate and rely on somebody else to read for them. Sometimes the constraints are geographical. Research centres are often distant from farmers not only in physical terms, but also in the way they present research materials, subjects and results. Such limitations need to be tackled and overcome.

While implementation of the rice programme is proceeding very well overall, there remain many other challenges. Establishing equal working and learning opportunities for men and women is one such major challenge in Bangladesh. Another challenge has to do with the way we measure success. Organizations are under pressure from government or donor agencies to demonstrate quantifiable outputs. This can impinge upon the quality of the service provided as well as on the principle of putting farmers at the centre. For example, a programme may have contractual responsibilities with donors to train a certain number of farmers annually in order to justify budget allocations. If the number is overestimated, the rush to reach this number before the end of the year will decrease the quality of the work and the sustainability of the learning process. The organization needs to protect the quality of its interventions by avoiding an excessive preoccupation with target numbers.

Conclusions

The rice programme is still learning from ongoing activities and innovations. It strives to be an education programme rather than just agricultural extension. Clearly, it has been quite successful in facilitating a process in which farmers can get more out of their rice fields. To what degree this is due to their increased capacity in decision making and management is not yet clear. It is clear, however, that it represents an improvement over the training-lecture types of programmes whose limitations are well known in terms of their doubtful sustainability, dubious quality and poor fit with farmers' needs.

The programme needs to continue to focus on giving farmers opportunities to take control of their own learning. The social, economic and cultural milieu in Bangladesh does not easily support this. To start working with poor and marginal farmers, it has been necessary to adopt specific and beneficial sustainable agriculture entry points that offer a high likelihood of success. But the programme must ensure that these remain entry points and not sole objectives. In any event, the high adoption rates and the increased returns from the innovations brought about by the programme attest to the appropriateness of the intervention. Longer-term impacts beyond the adoption of particular sustainable agriculture practices may be taking place but still remain to be measured.

Notes

1 The growers surveyed owned, on average, 0.45ha of land. Note: Through the 1999 Bellagio conference, CARE/Bangladesh learned about the system of rice intensification. Farmer field school participants using the System of Rice Intensification (SRI) methods in Kishoreganj district in 2000 averaged 6.5t/ha. Farmers cooperating with the Department of Agricultural Extension in Kishoreganj averaged 7.5t/ha with SRI methods.

2 48 takas = US$1. One kilo of rice (paddy) is worth 5–7 takas (US$0.10–0.14).

3 These data are from the NOPEST mid-term review and monitoring report.

4 In compiling results, the areas considered were ones with no climatic disasters during the three seasons.

5 Since a large part of the fish production is consumed by the household, potential net return – defined as the value of the harvest minus the cost of producing it – is used rather than actual net return.

6 As with fish, most vegetables are consumed, so potential net return – the value of the harvest minus the cost of producing it – is also used here.

7 Caring for seed is traditionally a woman's responsibility.

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10

New Meanings for Old Knowledge: The People's Biodiversity Registers Programme

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Introduction

All knowledge and wisdom ultimately flow from practices, but their organization differs among the different streams of knowledge. Folk knowledge is maintained, transmitted and augmented almost entirely in the course of applying it in practice; it lacks a formal, institutionalized process for handling. Folk ecological knowledge and wisdom are therefore highly sensitive to changing relationships between people and their ecological resource base. Today, both are eroding at a fast pace for two reasons: firstly, people now have access to newer resources such as modern medicines and are no longer as dependent on local medicinal plants and animals as before; and secondly, people are increasingly losing control over the local resource base, with takeovers by state and corporate interests (Gadgil and Berkes, 1991). However, folk knowledge and wisdom, with their detailed locality – and time-specific content – are of value in many contexts. They must therefore be supported in two ways: by creating more formal institutions for their maintenance and, most importantly, by creating new contexts for their continued practice (Gadgil et al, 1993). The programme of 'People's Biodiversity Registers' (PBR) is such an attempt.

It is a programme of documenting how lay people, primarily rural and forest-dwelling communities, understand living organisms and their ecological setting. The information recorded relates to present status as well as changes over recent

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years in distribution and abundance; factors affecting distribution and abundance, including habitat transformations and harvests; known uses; and economic transactions involving these organisms. The document also records the perceptions of local people about ongoing ecological changes, their own development aspirations, and their preferences as to how they would like the living resources and habitats to be managed. We summarize here our experience of developing the concept and organizing the preparation of 52 such PBRs in different parts of India, the resultant understanding, and the interest that this programme has generated (Gadgil et al, 1998).

We believe that the PBR process, involving a collaboration between people working in the organized sector (e.g. educational institutions, government agencies and NGOs) and the practical ecologists, peasants, herders, fishers and traditional healers (all in the unorganized sector), is as significant as the product: the recorded information. A subset of the information collected, especially that pertaining to medicinal and other economic uses, has been recorded by ethnobiologists working in academic institutions and for the pharmaceutical industry and other commercial interests (Reid et al, 1993; Martin, 1995). In this process, however, the local people are treated as anonymous informants; they receive no particular credit for their knowledge, and the information is accumulated with little reference to particular localities and times (Posey and Dutfield, 1996). The PBR process, on the other hand, aims to record the information with full acknowledgment of the source; it thereby serves as a possible means of sharing of benefits that may flow from further economic utilization of such information. Another subset of the information recorded in PBRs is collected during 'Participatory Rural Appraisal' (PRA) exercises (Chambers, 1992, 1993) that feed into decentralized development planning. Generating good information for such participatory development is also an objective of PBRs; the PBRs differ from PRAs in their greater emphasis on recording all pertinent knowledge, including changes over the recent past, and in giving specific credit for the information collected. Although we have so far completed only one round of PBRs in any one locality, we expect it eventually to become an ongoing process of monitoring ecological change and generating the necessary information for locally adaptive management of living resources.

Materials and Methods

The People's Biodiversity Register Programme was initiated by the Foundation for Revitalization of Local Health Traditions as a programme focused on documenting community-based knowledge of medicinal plants and their uses, through a workshop held at the Indian Institute of Science, Bangalore in April, 1995 (Gadgil et al, 1996). Workers from voluntary agencies participating in this workshop went on to compile, by mid-1996, what were termed Community Biodiversity Registers at 24 sites distributed over ten states of India. This experience suggested that it would be desirable to broaden the scope of the exercise to all elements of biodiversity, and to record knowledge and perceptions at all levels, from individuals, households and ethnic groups to multi-ethnic communities. Thus, the name of the programme was modified to People's Biodiversity Register. A second workshop to explore this broader approach was organized at Supegaon in Maharashtra in August, 1995. This was followed by initiation of PBR activities at ten sites in four states of the Western Ghats region, as a part of the Western Ghats Biodiversity Network Programme (Gadgil, 1996). These experiences laid the foundation of the current set of PBR preparation at 52 sites in eight states as a part of the Biodiversity Conservation Prioritization Programme of the World Wide Fund for Nature – India (Gadgil et al, 1998). The focus of this programme is on the conservation priorities and preferred strategies of the local people. The account that follows primarily refers to the third phase.

This programme was initiated through a workshop held in March, 1996 at the Indian Institute of Science, Bangalore, involving potential collaborators from the states of Himachal Pradesh, Rajasthan, Bihar, Assam, Orissa, Karnataka, Maharashtra and the Union Territory of Andaman and Nicobar Islands. These eight regions were selected to provide a good sample of the varied ecological and social regimes of the subcontinent. Discussions at this workshop permitted a crystallization of the methodology and drafting of a methodology manual termed Srishtigyan (Hindi: Srishti, nature; Gyan, knowledge). There followed a series of further training programmes and workshops that have facilitated the fieldwork spread over 52 sites throughout the subcontinent, employing a common methodology. The first task of the state-level coordinators was to select the individual study sites that would represent the entire spectrum of ecological and social regimes within the state (Figure 10.1 and Table 10.1). The 52 study localities cover all of the bioclimatic zones of the country (Gadgil and Meher-Homji, 1990): tropical wet (18 sites), tropical moist (16), tropical dry (6), tropical semi-arid (4), sub-tropical (4), temperate (3) and alpine (1). They also cover a whole range of ecosystem types: forest (30), pastures (8), wetlands (14), degraded forests (3), agriculture (33), horticulture (8) and deserts (3). Sixteen of the study areas are protected: six national parks and ten wildlife sanctuaries, three of which are tiger reserves and two are bird sanctuaries.

After study areas were selected, field investigators were chosen from among college – or university-level science teachers or workers of rural development or environment-oriented NGOs. Many of these people are from nearby localities, and have considerable previous familiarity with the study sites. The field investigating teams worked closely with, and often included, some of the local residents. Of the 52 principal investigators of the programme, 14 were college teachers, two university teachers and two school teachers. There were four government officials, 13 NGO workers and six individuals engaged in development activities on their own. The entire programme engaged 350 researchers from all of these sectors and 200 assistants from village communities. As many as 1000 villagers had extensive involvement in the programme as local knowledgeable individuals.

The methodology of field investigations included the following components: building rapport with local people, clarifying project rationale and obtaining local

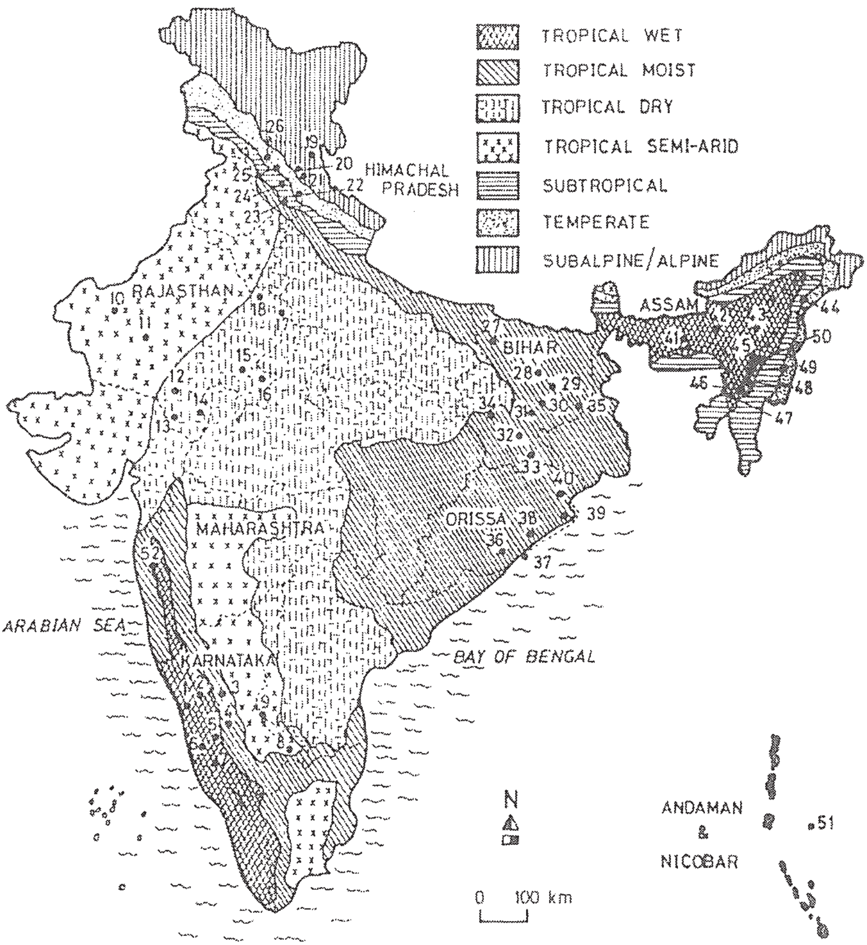

Figure 10.1 *041 Distribution of study sites across various bioclimatic zones in India. Site numbers refer to those in Table 10.1*

approval for the joint studies, identifying different biodiversity user groups, identifying individuals knowledgeable in different aspects of distribution and uses of biodiversity, interviewing individuals and groups with members representing different user groups, mapping the study site landscape, visiting representative elements of this landscape with some user-group members and knowledgeable individuals, and discussing resource use at the study area with the entire village assembly and with outsiders such as nomadic shepherds or artisans, traders and government officials. This methodology is spelled out in detail in the Srishtigyan manual (Chhatre et al, 1998).

Table 10.1 *Location, environmental setting, and names and affiliations of the investigators at each study site in India. Code numbers correspond to the site numbers in Figure 10.1*

Code	*Region/village*	*BCZ†*	*Ecosystems‡*	*PA§*	*Team¶*	*Principal investigator*
Karnataka State						
1	Holanagadde	TW	C		C	Prakash Pandit, H. M. Ganapathi
2	Kalase	TW	F		C	Dayanand Bhat
3	Kamadhodu	TW	A		S	Mahesh Gowda, T. S. Channesh
4	Neralekoppa	TM	F,A,H		C	C. K. Poojari
5	Kigga	TW	F,A,H	NP	C	G. K. Bhatta, P. Bhat
6	Mala	TW	F,A,H	NP	C	K. P. Achar
7	Subramanya	TW	F,A,H		C	K. N. Deviprasad
8	Gandlahalli	TS	A		I	Amar Prasad, T. S. Channesh
9	Chennekeshavapura	TS	A,P		I	P. R. Sheshagiri Rao
Rajasthan State						
10	Vrimdeora	TS	D		N	Hukum Singh Rajpurohit
11	Doli	TS	D		N	Sudhir Mathur
12	Bichiwara	TD	DF		N	Kavitha Gandhi, Mamta Bardhan
13	Mahad	TD	F,A	WS	N	Soumitri Das, Niraj Kumar Negi
14	Kewara	TD	F,A		C	R. K. Garg
15	Devli	TD	R,A		N,C	K. K. Dadhich
16	Dhikonia	TD	DF,A		N,C	Prahlad Dubey
17	Aghapur	TD	W		C	S. S. Jain
18	Mathurawat	TD	F		N	Manpal Singh
Himachal Pradesh State						
19	Shgnam	A	D		I	Chhewand Dorjezanpo
20	Shainshar	T	F,P	NP	N	Pawan Sharma, Joginder Negi
21	Karsog	T	F,P		I	Nek Ram Sharma
22	Kathog	T	F,P,H		N	G. Thakar, N. Thaltokhod

Table 10.1 *(continued)*

Code	*Region/village*	*BCZ†*	*Ecosystems‡*	*PA§*	*Team¶*	*Principal investigator*
23	Darlaghat	S	F,P,A,H		N	Des Raj, Hema Sharma
24	Kaihad	S	F,P,A		N	Gauri Datta, Naval Kishore
25	Rajai	S	F,P,H		I	Pameen Kotoch, Narendra Kumar
26	Banet	S	F,P,H		I	Man Singh Kapoor
Bihar State						
27	Udaipur	TM	W,A	WS	C,N	Ashwini Kumar
28	Kabar Lake	TM	W,A	WS(B)	C,N	Shankar Kumar, A. K. Mishra
29	Bhimandh	TM	W,F	WS	C	Pankaj Kumar, B. R. Sinha
30	Hazaribag	TM	F,A	WS	N,G	Pankaj Srivastava
31	Ranchi Town	TM	F,A		C,N	B. K. Sinha, A. K. Sinha
32	Dalma	TM	F,A	WS	N,G	D. S. Srivastava
33	Saranda	TM	F,A		C,N	Sulaiman Quli
34	Palamu	TM	F,A	NP(TR)	N,G	D. S. Srivastava
35	Udhwa Lake	TM	W,A		N,G	Pankaj Srivastava
Orrisa State						
36	Krushnanagar	TM	DF,A		N	Ashok Kumar Nayak
37	Berhampore	TM	W,A	WS	N	Manas Mishra
38	Dhani	TM	F,A		N	Rekha Panigarhi, Y. Giri Rao
39	Bhitarkanika	TM	W,A	WS	N	Rekha Panigarhi
40	Simlipal	TM	F,A	NP(TR)	N	Sanjeev Padhi
Assam State						
41	Rani-Garbhanga	TW	F,A,W		U	Mahendra Boro, Rathin Barman
42	Nameri	TW	F,A,W	WS	U	R. K. Das, Bebeka Bora, Talukdar
43	Majoli	TW	W,A		U,C	Debojit Baruah, Anand Hazarika
44	Dibru-Saikhowa	TW	F,A,W	WS	G,U	Narayan Sharma, R. Barman
45	Lamding	TW	F		U,C	Joshedev Arjun

Table 10.1 *(continued)*

Code	*Region/village*	*BCZ†*	*Ecosystems‡*	*PA§*	*Team¶*	*Principal investigator*
46	Sone Beel	TW	W,A		U,N,S	D. Kar, G. K. Das, M. Purkayastha
47	Sat Beel	TW	W,A		U,N	M. H. Burbhuia
48	Loharband	TW	F,A		U,N	Ranajit Das
49	Bhuban Hill	TW	F		U,N	D. Saha
50	Haflong	TW	F		N	R. A. Laskar, S. Thoasen
Andaman						
51	Rangat	TW	F,A		N	A. Chakraborty, Sameer Acharya
Maharashtra						
52	Shilimb	TM	F,A,P		I	Smita Botre

Notes:

† BCZ (Bioclimalic Zones): A, alpine; S, subtropical; T, temperate; TD, tropical dry; TM, tropical moist; TS, tropical semi-arid; TW, tropical wet.
‡ Ecosystems; A, agriculture; D, desert; DF, degraded forest; F, forest; H, horticulture; P, pasture; W, wetland.
§ PA (protected area): NP, national park; WS, wildlife sanctuary; B, birds; TR, tiger reserve.
¶ Team: C, college, G; government; I, individual; N, non-government organization; U, university.

Results

Living resources

Many widespread trends are evident in the 52 PBRs representing the entire spectrum of ecoclimatic and socioeconomic conditions of this diverse country. Agricultural production, especially of cereal grains, has increased over India as a whole, as has the production of wood from eucalyptus, poplar and *Acacia auriculiformis* plantations. Fish and shrimp production has also increased under aquaculture. These increases result from intensification of inputs and management. Outside such managed ecosystems, however, there has been widespread decline in both productivity and diversity of living resources. Such decline can be traced to a variety of factors: breakdown of social regulation of harvesting regimes; escalation in demand, well beyond the productive capacity of the resources, for meeting subsistence and market demands; deterioration in the productive capacity of resources attributed to adverse environmental changes such as pollution and siltation; and diversion of the land to other purposes such as mining and road construction.

We may cite here two examples of the breakdown in social regulation, one related to a breakdown of community-level understanding, and the other to a breakdown of localized authority. First, along several streams in the mountainous state of Himachal Pradesh, people used to observe a system of sacred pools called machiyals, where no fishing was permitted. This system of refugia promoted long-term persistence of fish populations fished elsewhere along the stream (Gokhale et al, 1998). Establishment of road communications has now rendered many parts of the state accessible to outsiders, such as military personnel who do not respect the protection to the machiyals. Simultaneously, road construction activity has led to widespread availability of dynamite, which is used for highly destructive fishing by such outsiders. This has led to considerable depletion of fish populations along these streams.

The second example comes from the semi-arid and arid state of Rajasthan, where extensive areas adjacent to villages were protected as sacred groves or orans, subject to highly regulated harvests, primarily of dead wood and fodder. These regulations were enforced by the village landlord families, mostly belonging to the dominant Rajput castes, until the land reforms around 1970. The orans were taken over as government property during land reforms. However, the government machinery did not act as an effective regulatory authority, so that most orans have become open-access resources subject to unregulated harvests, except for special cases such as Doli, which will be discussed.

Examples of excessive levels of harvests depleting already dwindling living resources of the public lands are part of every one of the PBRs. Resources so depleted include fuelwood, grazing, small timber for house construction, grass and palm leaves for thatching roofs, and medicinal plants. One village in Rajasthan was earlier named Vaidyonki Devli, Devli village of medicine men. With the depletion of all natural vegetation, including the medicinal plant resources, the villagers have removed the epithet Vaidyonki from the village name. The state of Himachal Pradesh has also witnessed a rapid depletion of medicinal plant resources with the manifold increase in commercial demand, for instance, for leaves of *Taxus buccata*, now known to contain an anti-cancer compound.

Living resources have declined through pollution. For example, several villages in Himachal Pradesh report the loss of honeybees, important for crop pollination, due to pesticide use. Fish populations of the large water body of Sone Beel in the Barak Valley of Assam have reportedly declined due to siltation following construction of a dam. Habitat change is another significant factor. In the village of Holanagadde in Karnataka, medicinal plant resources declined when the natural scrub created by lopping for fuelwood was replaced by an *Acacia auriculiformis* plantation.

The governmental agencies that control the public land and water resources more and more tightly have responded to this erosion of living resources by further restricting people's access without being equally effective in restricting the access of well-organized commercial interests. Thus, access to the Bharatpur National Park by Aghapur villagers has been strongly restricted, whereas the Darlaghat Wildlife

Sanctuary in Himachal Pradesh was delisted to facilitate the creation of cement plants.

Our PBRs do not, however, merely record instances of the degradation of living resources of public lands and waters. Two of the PBRs, pertaining to Doli village in Rajasthan and Dhani village in Orissa, record examples of the spontaneous establishment of regimes of regulated use, leading to resource recovery. The restrictions in Doli are the result of religious sentiments of a Hindu sect, the Bishnois, whose precepts call for protection of several species of plants and animals. At their instance, the local sacred grove (oran) has been well protected over the last 25 years (Gokhale et al, 1998). In the primarily tribal village of Dhani, the people on their own initiative have established a forest protection committee and have ensured excellent natural regeneration of the forest. We will discuss the Dhani experience further.

Practical ecological knowledge

People's dependence on living resources has declined along with the decline in ready availability of such resources to them. At the same time, people have access to new resources that can substitute, for example, allopathic drugs in place of herbal remedies, tiles in place of thatching for roof, or synthetic dyes in place of vegetable dyes. This has led to a decline in interest, among the younger generation, in the knowledge of living resources, a decline reinforced by the modern, largely bookish system of education. Our PBR studies reflect such decline in knowledge. In Kaihad village in Himachal Pradesh, residents as a whole know of ~ 450 species of plants and animals. However, while those 50 years or older can identify ~ 70 per cent of local flowering plants, characterize 40 per cent and mention uses for 5 per cent, the respective percentages decline to 25 per cent, 4 per cent and 1 per cent among people 30–50 years old, and to 0 per cent among younger people.

This is not universal, however. In predominantly fishing communities, such as Berhampur village near Chilika Lake in Orissa, much ecological knowledge persists among youth who continue to be engaged in fishing as a profession. Similarly, knowledge and use of medicinal plants is still common among all sections of the population, including the youth, in Mala village in Karnataka.

People affected

The starting point of the PBR exercise is to classify the concerned human population into 'user groups' on the basis of their relation to natural, particularly living, resources. Thus, cultivators owning sufficiently large tracts of land to fulfill their household biomass requirements may constitute one group; landless agricultural laborers dependent on public lands for their biomass requirements, such as fuelwood or dung, and on weaving baskets or mats for employment in the non-agricultural season, may constitute a second group, and specialist herders a third group. Within households, women assume greater responsibility for fuel and fodder collection than

Table 10.2 *Distribution of knowledge of a variety of specific uses of 173 plant species among different human communities of Shilimb village in Maharashtra State, India*

Kind of uses	*Communities*		*Katkaris*	*Dhangars*	*Brahmins*
	All 13	*At least 10*			
Human medicine	2	9	57	16	9
Veterinary medicine	1	1	1	3	1
Food	45	46	56	49	45
Fodder (cattle)	0	0	0	5	0
Fodder (sheep)	0	0	0	4	0
Agricultural implements	2	13	8	13	1
Ropes	3	4	4	4	4
Fuelwood	4	4	4	4	4
Fish poison	0	0	4	0	0
Other commercial uses	0	1	7	1	1

Note: Table entries are numbers of plant species.

men; hence, women from poor, landless families may constitute a distinct user group. PBRs show that greater dependence on living resources is also accompanied by much greater knowledge. For instance, in Shilimb village in Maharashtra, 13 distinct endogamous groups fall into five major user groups. Brahmins are substantial landowners and traders, Katkaris are landless agricultural labourers, Dhangars are specialist herders, and the other ten endogamous groups are divided into cultivators with medium-sized holdings and artisans. As Table 10.2 shows, Katkaris are by far more knowledgeable about uses of plant species. As may be expected, they are also reported to be the user group to suffer most from a degradation of the living resources of Shilimb. Similarly disadvantaged user groups are susceptible everywhere to suffering most from greater loss of access to public lands and water. For instance, similar groups in several PBR sites from Palamu National Park in Bihar are currently being asked to move out of their century-old settlement sites within forest areas.

Motivation

The PBR exercise involved recording the development aspirations of all of the different user groups at different sites. The citizens of India today uniformly equate development with higher incomes and upward social mobility. Everywhere, the wealthy and the powerful have better access to transport and communication, health care, education and water for household use and irrigation; all segments of society aspire for enhanced access to these resources as the core of development. In contrast, the people most dependent on and knowledgeable about biodiversity are, without exception, the poorest and least powerful. Better access to biodiversity resources and their conservation therefore tend to be viewed as (no doubt) desirable, but certainly not an integral component of development aspirations. Almost no segment of the rural population today is strongly motivated to organize and participate in efforts at conservation and sustainable use of biodiversity.

The PBRs also record the perceptions of the rural population about the current role and motivation of other major agents influencing the living resources, namely government agencies such as forest departments, and traders and industry. The government agencies are reported as being self-serving, corrupt and inefficient, the commercial interests as being motivated to pursue short-term profits. None of these agents is reported to be motivated to promote long-term conservation and sustainable-use objectives.

Resultant conflicts

PBRs document that almost all segments of the society in all study sites are committed to utilizing living resources in their own, often very divergent, short-term interests. This results in a variety of conflicts at many levels. A sample of conflicts recorded in the PBRs of Himachal Pradesh follows: (1) Within households, men and women differ on household use *vs* marketing of wood, and therefore in the choice of species to be planted on public lands. (2) Within a village, different user groups differ on the desirability of maintaining grazing lands for livestock *vs* planting these lands with trees that produce leaf fodder. (3) Within a village, the land-less households would like some of the public lands to be made available to them for cultivation, whereas landholding user groups would like them to be retained for fuelwood or fodder plantations or grazing lands. (4) There are conflicts among neighbouring villages on access to fuelwood and grazing and on the level of protection to be offered to plantations. (5) Villagers settled permanently on land come in conflict with nomadic herders on access to grazing and fodder. (6) Villagers come in conflict with traders in the collection of medicinal plants. (7) Villagers are in conflict with industry over the mining of limestone from forest lands traditionally managed by villagers. (8) Villagers are in conflict with the forest department over control of land earlier regarded as village common lands, over demands for compensation for damage to crops by wildlife and over management of village forest committees. (9) Villagers are also in conflict with the Public Works Department on damages suffered during road construction.

Lessons learned

PBRs include a discussion with the different user groups and with the village assembly as a whole on their prescriptions as to how the living resources should be managed. Although, as previously noted, the villagers do not include programmes for conservation and sustainable use of these resources as a part of their development aspirations, they uniformly note their unhappiness at the deterioration of this resource base. Their prescriptions for its good management overwhelmingly call for empowerment of local communities to play this role. They are, however, clear that local communities cannot on their own shoulder the responsibility; they need to be supported in many ways. Such support is needed to resolve conflicts within the village society, with neighbouring villages, and with commercial interests and the government agencies. All PBRs therefore suggest the institution of some form of co-management, cooperative arrangements among villagers, local educational institutions, NGOs and government agencies. There is considerable variation from user groups, from village to village and from one part of the country to the other, in the form of the suggested institutions.

Designing institutions

Given the broad consensus on the desirability of organizing community-based management systems, the various suggestions are best examined in the context of Ostrom's (1990, 1992) seven principles of design of long-enduring, self-organized systems. Clearly, it is not feasible to establish fully autonomous, self-organized systems on any widespread scale in the present-day Indian context (Gokhale et al, 1998). That is why the PBRs call for systems of co-management involving substantial support by government agencies to the community-based institutions as the appropriate arrangement (Gadgil and Rao, 1995). Ostrom's principles provide useful pointers to the most important areas in which local communities need to be supported by the state apparatus and other agencies, such as educational institutions and NGOs, to create viable decentralized institutions of management of natural resources.

Principle I – Boundaries of the managed resource should be well defined, and such a resource should be under the reasonably secure control of a well-defined human group.

At present, the living resources on public lands and waters are under the control of state agencies with boundaries defined by a system of land settlement as revenue lands, reserve forests, irrigation tanks and so on. However, the state agencies have a far from secure control over these resources, many of which are subject to abuse as open-access resources. In their stead, a new, decentralized system of governance called Panchayat Raj, with elected representatives from the level of village councils upward, is being put in place all over India (Singh, 1994). Many user groups support such an alternative arrangement; others express some doubts as to its efficacy. The unwillingness of government agencies to give up their own powers and to place resources under the secure control of Panchayat Raj institutions seems to be a major difficulty. Other problems arise in the case of fugitive resources, for example, river water affected by upstream influences such as water withdrawal or pollution. PBRs emphasize the need to set up proper machinery to resolve such cross-border conflicts.

Principle II – Groups responsible for resource management should be effectively organized.

Our PBRs record several misgivings about the efficacy of Panchayat Raj institutions to manage the living resources of public lands and waters. In part, these relate to the large number of people, in the order of 10,000, within the boundary of a panchayat. Self-organized management institutions are much more effective when they involve smaller, more homogeneous groups in face-to-face contact. Therefore, people in many of the study localities suggest that parallel committees representing smaller groups, working as subsidiary bodies of Panchayat Raj institutions, are more appropriate to take on tasks of natural resource management.

Principle III – Long-term benefits of conservation measures should be commensurate with the costs incurred.

Conservation measures entail certain restraints on the immediate use of resources, or on conversion of the land or water areas to alternative uses. These would imply certain opportunity costs. Conservation measures may also entail other costs such as crop depredation and killing of livestock or even of people by wild animals. These costs need to be effectively offset by benefits, which would generally be realized in the longer term. Furthermore, the costs would not be borne, nor would the benefits flow, equally to the different user groups. Management needs to be tailored to the time, locality and society-specific conditions. The PBRs bring this out well. For example, Himachal Pradesh sites might require rather special arrangements with nomadic herders who visit annually; these are irrelevant to other sites. Even with such flexible arrangements, the benefits may not be adequate to offset costs. Many PBRs therefore propose additional benefits, in the form of either social recognition or financial incentives. Thus, the village Doli in Rajasthan, which protects a large sacred grove with a substantial population of antelopes that inflict much damage on crops, may deserve payment of an annual service charge in recognition of its contribution to nature conservation. Such a service charge may take the form of a special annual grant by the Rajasthan State Government to the village council concerned.

Principle IV – Machinery enforcing the observance of management rules should be accountable to, and respected by, the actors.

Government agencies such as the Forest Department today are in charge of monitoring observance of resource use regulations, except in a few special cases such as the Doli village in Rajasthan. All of our PBRs suggest that this machinery is viewed to be self-serving, corrupt and inefficient, in no way accountable to people. Suggested alternatives include committees of local people working with a transparently functioning and people-oriented government machinery, assisted by local educational institutions and NGOs.

Principle V – Agreements should be arrived at on the basis of collective choice.

Currently, the resource use prescriptions are imposed from outside by a government apparatus that has no accountability towards local communities. All of our PBRs propose that this be replaced by a process in which the local community is actively involved in consultation with concerned government agencies and other actors such as educational institutions.

Principle VI – The management rules should be flexible.

Principle VII – Sanctions against those violating the rules should be imposed in a graduated fashion.

The centralized management agencies tend to impose uniform and rigid rules and sanctions against violations. All of our PBR exercises point to the need for flexibility and fine-tuning to the specific situation. An excellent example of this is provided by the working of the Forest Protection Committee formed at the initiative of people from a cluster of five villages around Dhani in Nayagarh district of Orissa. This management system was initiated in 1986 in response to extensive degradation of forest stock under government management. To begin with, the Forest Protection Committee banned all collection of forest produce, as well as grazing and encroachment for cultivation, in the 800ha plot. Initially, fines for violation were collected on the basis of the kind of produce extracted. After two years of strict protection, the forest began to regenerate and the Forest Protection Committee decided to permit extraction of leaves and fruits and grazing by livestock. After a further period of regeneration, there was further relaxation, permitting collection of fuelwood for household needs, but without any felling of green trees. At the same time, a few of the poorest families are now allowed to collect a limited quantity of fuelwood for sale as well.

Adaptive Co-management

The very broad consensus from our PBR exercises is the need to establish community-based systems of resource management supported by, and working in collaboration with, concerned governmental agencies, educational institutions and, where appropriate, NGOs. There is also a clear endorsement of the need for these management systems to be flexible and tailored to specific situations. Such systems may be termed as systems of adaptive co-management (Walters and Hilborn, 1976). The process of preparation of PBRs, as well as the product (the record created), emerge as very useful devices in such adaptive co-management systems (Anonymous, 1996). The value of the PBR process is exemplified by an experience in the village Nanj from the Karsog study area of Himachal Pradesh. The village was an active participant in the literacy movement during 1992–1993 and the people were exposed to a variety of issues relating to natural resource management. As a consequence, there was consensus to enclose a heavily degraded patch of forest. Regeneration on this patch has been extremely promising. During the literacy campaign, a blackboard was painted on a wall at a public place in the village for open classes and dissemination of information. Over the last few years, it had fallen into disuse, but it was revived during the PBR documentation to display the information collected, leading to public debates on the issues and, in turn, to conservation actions.

One such debate centred around the species kambal (*Rhus wallichi*, Hook, f.), a multi-purpose tree found up to the mid-Himalayas, considered to be a good source of fuelwood and green manure. It was pointed out, using the blackboard, that excessive pressure of both fuelwood and manure collection had reduced the kambal to a bush in the forest, leading to declining availability of both fuelwood and manure. After many days of discussion in front of the blackboard, it was decided that leaf manure for ginger was a higher priority. As other fuelwood species were available in the forest, it was agreed to restrict the extraction of kambal to leaves for green manure, with bushes pruned in such a way that one or two shoots would be permitted to grow. At the same time, a few progressive farmers decided to experiment with agricultural crop residues as a substitute for kambal leaves for manure. Over one year, they demonstrated that there was no difference in the yields from the two kinds of manure; subsequently, more farmers turned to crop residues as this meant lower labour inputs. As a consequence, kambal is now flourishing in the forest and through careful pruning and good rootsrock, it will grow back to tree size in a few years.

The documentation of natural resources, the history of their use, people's development aspirations, ongoing difficulties in resource management in the form of manifold conflicts, and people's prescriptions on how the resources should be managed are clearly very pertinent inputs for any system of adaptive co-management. The PBR of Berhampur village near Chilika in Orissa furnishes an interesting example of such a product. Chilika, the largest brackish-water lagoon in South and South East Asia, is under manifold threats. These arise because of the escalating pressures on natural resources: forests in the catchment that have been felled, surrounding fields that are sprayed with pesticides, or fish stocks that are caught in increasing numbers with mechanized boats and fine-meshed nylon nets. It is obviously impractical to think of going back to the old days when most resources were used far less intensively. However it is essential to manage the resources far more carefully.

In this, practical ecologists, such as the fisherfolk of Chilika, can provide valuable inputs, for they are the people with a serious long-term stake in the health of their environment. Table 10.3 summarizes the management prescriptions flowing from our PBR exercise in Berhampur village.

Benefit sharing

The PBR document could also serve a very useful function in implementing article 8(j) of the Convention on Biological Diversity (UNEP, 1992); this article calls for approval of local people in promoting wider use of their knowledge and sharing with them the benefits of such commercial utilization of knowledge. This is a difficult task, as some of this knowledge is already in the public domain, leaving no bargaining power with the providers. The remaining knowledge is variously distributed across communities and individuals, and is being actively tapped by the researchers and entrepreneurs, often violating the spirit of the CBD provisions (Volker, 1997). The issues may be illustrated by a concrete experience in the village Mala from Karnataka, notable for its continuing extensive use of herbal medicine. Mr. Kunjeera Moolya is the most knowledgeable of the dispensers of herbal medicines in Mala; he does not charge for his services, but makes a living as a farm

Table 10.3 *Conservation issues and measures identifies as possible solutions by fisherfolk of Chilika Lake in Orissa State, India*

Issues	*Measures*
Siltation	Dredging of inner and outer link channels. Soil conservation involving plantation and embankment.
Weeds	Increase in the salinity level of Chilika by opening the mouth and link channels. Biological control by introducing carps.
Water pollution	Limited use of motor boats. Ban on chemical food mainly used in prawn culture. Embankment around Chilika. Checking industrial pollution.
Prawn culture	Banning of spawn collection. Involvement of coast guards. Ecological training to the prawn culturists.
Increased fishing intensity	Alternative income sources for the locals. Revitalizing involvement of existing cooperative institutions. Check on the immigration of refugees. Check on the use of fine-mesh nets.
Encroachment	Survey and resettlement. Eviction of the encroachers. Restoring the traditional rights of the locals.

labourer. Moolya was approached in March 1995 by an agent of some pharmaceutical firm to disclose his knowledge of local medicinal plants. He went around the forest for two days and shared this information, for which he was paid a sum of Rs. 220 (US$6), equivalent to his normal earnings over four to five days. This agent evidently represented some pharmaceutical company engaged in screening Indian plant resources for possible commercial products.

The best organized of such programmes is run by Hoechst Marion Roussel India, a subsidiary of a multinational company of German origin (Volker, 1997). Hoechst runs a research unit in Mumbai, established in 1972 and described as a target-oriented lead discovery centre from natural origin. It employs some 70 PhD-holding scientists, all but the director being Indian citizens. Indigenous information, obtained from people like Moolya, as well as from published literature and modern electronic databases, is used to provide clues to rationalize the search for plants with interesting biological activities. The published literature includes that from the older tradition of Ayurveda and the modern tradition of ethnobotany. In neither of these traditions is there is any detailed, specific acknowledgment, at the level of local knowledgeable individuals, of the source of such information. Only three of the scientists employed by the Hoechst Research Centre are engaged in collecting samples of plants, fungi and microorganisms; others are busy with screening, toxicology and investigations of chemical modes of action.

Obviously, Hoechst would pay very many people like Moolya small sums like Rs. 220, and then pool together all the information generated with other public knowledge (such as of Ayurveda) and inputs from many scientific disciplines, to eventually develop a small number of products (Sukh Dev, 1997). The process may take many years, perhaps decades, and particular pieces of information provided by a specific individual may or may not yield any product. In any case, every product will use many other inputs in its development. It is therefore difficult to design a system of either regulating collection and use of such knowledge, or ensuring payment of royalty to a particular individual in case his/her knowledge provided an important clue. Furthermore, because much of such knowledge is part of shared cultural resources, there are questions of whether it is appropriate to reward any particular individual who may by chance have been the person to communicate a specific piece of information.

Given these complexities, our approach was to put on record only such information as was voluntarily disclosed by people without any persuasion on the part of investigators. Beyond this, other information was maintained off the formal record as claims, for example, that a particular person in village Kigga of Karnataka has an herbal remedy against snakebite. Such broad claims could subsequently be made public and may attract entrepreneurs to directly contact the claimants. The two parties may then negotiate terms under which the information may be revealed. Elsewhere in the world, innovative experiments of recording such exclusive, undisclosed information through various types of contracts are being initiated (Glowka, 1998). In Eucador, a project by the Inter-American Development Bank attempts to computerize traditional knowledge, segregated according to communities. The database manager, a local NGO, compares this with the public-domain knowledge listed in the NAPRALERT database housed at University of Chicago, Chicago, Illinois, USA. Knowledge not yet in the public domain is treated as trade secrets, and is transferred to potential users directly by the corresponding community or an intermediary, through agreements. Further, the NAPRALERT information that is unavailable to the people is also repatriated. On the other hand, know-how licences are negotiated between Aguaruna people from Peru and Searle and Company, the pharmaceutical division of Monsanto, irrespective of whether or not the knowledge was in the public domain. The licence brings the Aguaruna collection fees, annual know-how licence fees and milestone payments as the research progresses. The Aguaruna are also trained locally and in the university, are kept informed of the research progress and retain all the rights to resources as well as the right to terminate the licence. The Costa Rica Biodiversity Act also proposes a national registry of traditional knowledge. However, this will be used only to deny intellectual property rights to innovations with similar applications (Dutfield G. personal communication). In this case, the incentive for the people to record their knowledge is not obvious.

Apart from such one-to-one deals involving intellectual property rights, PBRs may also serve as a tool of conserving and respecting folk knowledge and rewarding through a different route, namely a system of awards linked to the quality of documentation of knowledge through PBRs (Gadgil, 1997). The state, international agencies such as UNEP or UNESCO, or private foundations may come forward to periodically reward the communities, in terms of special development grants and social recognition for excellence in documenting such folk knowledge. This would help to conserve such knowledge through creation of more permanent records, as well as to encourage the younger generation to acquire and keep it alive (Anonymous, 1996).

Prospects

The experience of preparing these 52 PBRs has been most positive, with considerable enthusiasm generated among teachers and students in educational institutions, among NGO activists and among members of local communities. An account of the experience appeared in the Annual Survey of Environment for 1998 published by *Hindu*, one of the leading English-language newspapers of south India (Gadgil et al, 1998). A large number of people from all over India have expressed an interest in undertaking PBR exercises in their own area, as a result of this exposure. Similar interest has been expressed from Brazil and South Africa as well. More concretely, the government of India, in its draft biodiversity act (Anonymous, 1998) tabled in the parliament session during April 1999, has specifically entrusted to the village councils the responsibility of documenting biodiversity resources, knowledge, and conservation efforts. Further, the bill provides for direct sharing of royalties from the commercial application with the individual or group of people only if the exclusiveness of the knowledge or resources that they provided can be ascertained. In all other cases, part of the benefits generated from commercial application of biodiversity and related knowledge would be deposited in a national fund. This national fund would be used primarily for rewarding and encouraging conservation efforts and knowledge contributions. Although the bill does not specifically mention the village documents as the basis for benefit sharing, it would eventually become imperative for the government to do so. Interestingly enough, without waiting for the government initiative to take off, the NGO group that coordinated this exercise in the state of Himachal Pradesh is seriously pursuing a follow-up, with many more PBRs being prepared throughout the state, primarily as a tool for adaptive co-management. A similar effort is on in 60 panchayats in the district Ernakulam of Kerala. This would be part of the vigorous attempt to decentralize development planning in the state. Other NGO groups from Karnataka and Andhra Pradesh are also preparing PBRs in several villages, with the expectation that these would also serve to protect people's rights over resources and knowledge. We are attempting to computerize the information contained in PBRs and to develop systems of synthesizing this information at higher spatial scales, such as districts and states. Eventually, the relevant, spatially aggregated information can be fed back to people so that they can benefit from learning about uses, trade value or conservation efforts in other areas. In the long run, we have every hope that PBRs will evolve into a useful tool supporting a process of community-based management of living resources, contributing to conservation, and the rewarding of folk knowledge.

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Part III

Governance and Education

11

From Extension to Communication for Innovation

C. Leeuwis

Historical Roots and Evolving Conceptions of Extension

The meaning of the term 'extension' has evolved over time, and has different connotations in different countries. In this section we touch on such different conceptions.

Origins, early meanings and international terminology

Throughout history, and across the world, there have existed patterns of agricultural knowledge exchange, with some people (e.g. religious leaders, traders, elders etc.) often playing special 'advisory' roles in this respect. According to Jones and Garforth (1997), more or less institutionalized forms of agricultural extension existed already in ancient Mesopotamia, Egypt, Greece and Phoenicia. The term 'extension' itself is more recent; it orginates from academia, and its common use was first recorded in Britain in the 1840s, in the context of 'university extension' or 'extension of the university'. By the 1880s the work was being referred to as the 'extension movement'. In this movement the university extended its work beyond the campus. In a similar vein, the term 'extension education' has been used in the US since the early 1900s to indicate that the target group for university teaching should not be restricted to students on campus but should be extended to people living anywhere in the state. Here extension is seen as a form of adult education in which the teachers are staff members of the university.

Most English-speaking countries now use the American term 'extension'. In other languages different words exist to describe similar phenomena. The Dutch use the word *voorlichting*, which means 'lighting the pathway ahead to help people find their way'. Indonesia follows the Dutch example and speaks of lighting the way ahead with a torch (*penyuluhan*), whereas in Malaysia, where a very similar

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language is spoken, the English and American word for extension translates as *perkembangan*. The British and the Germans talk of *advisory work* or *Beratung*, which has connotations of an expert giving advice but leaving the final responsibility for selecting the way forward with the client. The Germans also use the word *Aufklärung* (enlightenment) in health education to highlight the importance of learning the values underlying good health, and to emphasize the need for arriving at more clarity on where to go. They also speak of *Erziehung* (education), as in the US where it is stressed that the goal of extension is to teach people to solve problems themselves. The Austrians speak of *Forderung* (furthering) meaning something like 'stimulating one to go in a desirable direction', which again is rather similar to the Korean term for 'rural guidance'. Finally, the French speak of *vulgarisation*, which stresses the need to simplify the message for the common man, while the Spanish sometimes use the word *capacitacion*, which indicates the intention to improve people's skills, although normally it is used to mean 'training'.

Evolving definitions

Enlightenment definitions of extension

Initial meanings of the term 'extension' – as well as international equivalents of the term – have been influenced significantly by 'enlightenment thinking'. Although different nuances exist, the basic thrust is that 'the common folk' are to a degree 'living in the dark', and that there is a need for well-educated people to 'shed some light' on their situation by means of educational activities. This reflects that the early conceptions of extension were somewhat paternalistic in nature; that is, the relationship between the extensionist and their clients was essentially looked at as being similar to the teacher/student or parent/child relationship, placing the extension agent in an 'expert' and 'sending' position and their audience in a 'receiving' and 'listening' role. In line with this tradition, many definitions of agricultural extension emphasize its *educational* dimensions:

> Extension is a service or system which assists farm people, through educational procedures, in improving farming methods and techniques, increasing production efficiency and income, bettering their levels of living, and lifting social and educational standards. (Maunder, 1973, p3)

> Extension is an ongoing process of getting useful information to people (the communicative dimension) and then assisting those people to acquire the necessary knowledge, skills and attitudes to utilise effectively this information and technology (the educational dimension). (Swanson and Claar, 1984, p1)

It must be noted that each definition is a product of its time. When 'enlightenment' conceptions of extension were formulated there was still a firm belief in the potential and blessings of science as an engine for modernization and development, and there was a genuine concern that everybody should be able to pick the fruits of science. The belief then was that by adopting science-based innovations, and by grounding their practices and decisions in rational scientific insight and procedures, farmers and agriculture would benefit almost automatically. In view of the experiences of the last decades, however, science has nowadays become much more contested and the belief in science as a neutral and objective engine to progress has eroded significantly (Knorr-Cetina, 1981; Callon et al, 1986; Van der Ploeg, 1987; Beck, 1992). Although science has contributed significantly to agricultural change and production increases in high potential areas, its impact in other regions has remained much more limited. Moreover, science-based agriculture in high potential areas was accompanied by a number of serious problems related to, among other topics, the environment and health. Furthermore, even in high potential areas scientists regularly produced innovations and recommendations that were of limited use to many farmers. It was realized that successful innovation required as much input from farmers themselves as from scientists.

In line with 'enlightenment' thinking, there was great concern in the 1950 to 1970 period with the 'adoption and diffusion' of science-based innovations. Extension scientists developed an interest in so-called adoption *decisions*. In the context of diffusion, it was also recognized that farmers could gain a lot from each other's knowledge and experience (regarding new technologies, among other topics) when solving agricultural problems (Van den Ban, 1963). Inspired by such interests and insights, the emphasis in definitions of extension shifted slightly from 'education' to supporting *decision making* and/or *problem solving*:

> Agricultural extension: Assistance to farmers to help them to identify and analyse their production problems and to become aware of the opportunities for improvement. (Adams, 1982, pxi)

> Extension is a deliberate and systematic attempt – by means of the transfer of knowledge and insight – to help and/or develop someone in such a way that the person is able take decisions in a specific situation with a maximum level of independence, consciousness, and conformity with his own interest and well-being. (Van Gent and Katus, 1980, p9, translated by the authors)

> Extension involves the conscious use of communication of information to help people form sound opinions and make good decisions. Van den Ban and Hawkins, 1996, p9)

The last definition is the one which was used in the predecessor of this book (Van den Ban and Hawkins, 1996). Like most definitions presented so far, it still carries the idea that extension is mainly about 'help' in the interest of the farmer.

Intervention definitions of extension

The definitions mentioned so far are in essence *normative* definitions, in that they indicate what the authors feel extension *should* be and/or *should do*. In other words, they 'prescribe' what the authors *would like* extension to look like ideally, e.g. as a practice that is experienced as 'help' and 'assistance' and leads to 'good decisions' and 'development'. Alternatively, one could also try to define extension more descriptively in terms of what people who call themselves extensionists *actually do*, which frequently might not correspond with normative definitions (see also Röling and Kuiper, 1994). When taking a closer look at what extensionists do in practice, one might, for example, discover in some cases that their work has little to do with 'help' but rather with imposing technologies and/or enhancing state control over farmers (e.g. Ferguson, 1990). Along these lines, it was recognized during the 1980s that extension could not just be regarded as 'help' and 'being in the interest of the recipient'. It was realized that extension is in many ways also an *intervention* that is undertaken and/or paid for by a party who wants to influence people in a particular manner, in line with certain policy objectives. Thus, it was realized that there was often a tension between the interest of the extension organization (and/or its funding agency) and the interest of recipients such as farmers. Government extension services could, for example, aim at increasing the production of export crops, while farmers would be more interested in other issues or crops. In this more descriptive conception of extension, there needed at least to be a partial *overlap* or *link* (see Röling, 1988) between the interests of clients and extension organizations, otherwise people would obviously not be willing to change (unless they were forced/persuaded to by other means than just extension messages). In line with such views new definitions of extension emerged:

> Extension is helping behaviour consisting of – or preceding – the transfer of information, usually with the explicit intention of changing mentality and behaviour in a direction that has been formulated in a wider policy context. (Van Woerkum, 1982, p39, translated by the authors)

> Extension is a professional communication intervention deployed by an institution to induce change in a voluntary behaviour with a presumed public or collective utility. (Röling, 1988, p49)

The phrase added by Röling on 'presumed public or collective utility' is important, because it was used to distinguish extension from other forms of communication – intervention such as:

- *Commercial advertising*, where the goal is to sell products in the interest of a limited group (salesmen, shareholders).
- *Political propaganda*, where the goal is to influence people's ideological beliefs and/or perceptions of reality in order for some to gain or maintain power.
- *Public relations*, where the goal is to manage one's own reputation or public image.

At the same time, this phrase exemplifies that these definitions still contain normative elements. After all, it is more or less implicit in Röling's definition that extensionists should not be involved in, for example, trade, advertising or political propaganda, and if they are this cannot be regarded as 'extension'. As Röling and Kuiper (1994) point out, it is impossible to avoid normative elements in a definition of extension if one's purpose is not only to study extension as a societal phenomenon, but also to inform extension practitioners on how they can do better. From a purely descriptive point of view, the definition of extension would be something like:

> Extension is everything that people who think of themselves as extensionists do as part of their professional practice.

A book written on the basis of such a definition of extension could reveal very interesting activities and phenomena, but as soon as one wants to draw lessons for a wider audience one needs to assume certain criteria as to what it is, and is not, that extension aspires to, and how.

Extension as communication for innovation

The two 'intervention' definitions of extension still start largely from the premise that extension derives from a semi-state institution that is concerned with the public interest or public policy. This situation is rapidly changing in view of the emergence of private and NGO-based extension and communicative intervention. In addition, we need various changes in the definition of extension if we are to take the challenges seriously. These include a need to:

- Shift away from a focus on *individual* behaviour change which has characterized most of the definitions so far, and incorporate the idea that extension is about fostering new patterns of coordination.
- Move away from the idea that extension works mainly on the basis of *predefined* directions, policies and innovations, and emphasize its *generative* dimensions.
- Indicate that changes usually have a dual (material-technical and social-organizational) component.
- Transcend the idea that extension is mainly concerned with decision making, and emphasize the importance of *social learning* and *negotiation* in extension processes.
- Define extension as a *two-way* or *multiple-way* process, in which several parties can be expected to contribute relevant insights, and which may have action implications for all parties (not only farmers, but also researchers, extensionists, policy makers, agricultural industries etc.) involved in the process.

In view of such significant needs for redefinition (see also Sulaiman and Hall, 2002), some senior authors in the field of extension have chosen to completely *abandon* the notion of 'extension' altogether (e.g. Röling and Wagemakers, 1998; Van Woerkum et al, 1999; Ison and Russell, 2000). They feel that the word 'extension' has misleading connotations, and that it is practically impossible to stretch the meaning of the concept as necessary. In line with this, Van Woerkum and

Röling no longer use the concept in many of their writings, and they have in their university renamed the field of Extension Science as Communication and Innovation Studies. Similarly, Ison and Russell (2000) speak of 'second-order research and development'. In many ways we agree with such proposals to move away from the term 'extension'. The main reason why we still use the term is that this text is aimed not just at a small group of academics, but also at a wider group of practitioners in training and management positions of which many still identify strongly with the term 'extension'. However, this group is likely to erode, while alternative audiences who do similar work are likely to expand. Hence, we have chosen to start with the term 'extension' and emphasize the need to change our conception of it. In view of the above, we propose to define extension as:

> a series of professional communicative interventions amid related interactions that is meant, among others, to develop and/or induce novel patterns of coordination and adjustment between people, technical devices and natural phenomena, in a direction that supposedly helps to resolve problematic situations, which may be defined differently by different actors involved.

Or in a more condensed form:

> a series of embedded communicative interventions that are meant, among others, to develop and/or induce innovations which supposedly help to resolve (usually multi-actor) problematic situations.

Let us look more closely at some of the ingredients of this, mainly descriptive, definition:

1 The definition maintains that extension is a *professional* activity, practised by people who are somehow paid and/or rewarded for it. We do not call everyday communicative interactions, for example, between farmers, 'extension', even if they contribute to innovation.
2 Extension is regarded as an *intervention*, as it is usually subsidized or paid for by external agencies (donors, governments, private companies) whose aspirations for doing so are not the same as those of the supposed beneficiaries. Nevertheless, extension can only be effective if there is sufficient overlap or compatibility between the aspirations of change agents and clients.
3 Extension draws heavily on *communication* as a strategy for furthering aspirations. Communication is the process through which people exchange meanings (e.g. through the use of information). Thus, extension is an activity that is geared towards bringing about *cognitive* changes, used as a trigger for other forms of change (e.g. human practices, growth of crops, water availability, regulations). At the same time, the emphasis on 'communication' marks a shift away from a focus on *education* to a focus on *learning*.
4 Extension is a *process* involving a *series* of communicative interventions and interactions. It is not a once-only event. People respond to communicative

interventions, and such interventions have consequences, which usually bring about other communicative interventions.

5 Extension takes place *amid other interactions*, which indicates that there are many other interactions going on between people that do not involve extension and/or change agents, but which are still very relevant to the process. Farmers in a village, for example, interact a lot with each other, with other service providers and with community and/or religious leaders, and this is bound to have an impact on innovation processes.

6 Although communication workers are usually interested, albeit with different degrees of intensity, in bringing about change and innovation of some kind, we cannot explain the dynamics of the process by just looking at such intentions. Whenever people interact, multiple goals and intentions play a role. Change agents too may have *other aspirations*, some very mundane, that impinge on the way they go about their work; these may include pleasing their boss, aquiring social status, enhancing control over farmers, reserving time for side-line activities, visiting home regularly etc.

7 The statement that extension aims to '*develop and/or induce*' innovation emphasizes that we cannot simply look at extension as 'dissemination of innovations'. Frequently, extension activities are, or need to be, geared towards designing new innovations. And even if extension activities aim at the 'diffusion' of existing innovation packages, this can often not be effective without including elements of 'redesign'. The term 'to induce' is chosen here to capture this mixture of dissemination and adaptation. The definition does not further specify what *kind* of processes are involved in 'developing' and 'inducing', thus leaving space for all sorts of social processes, including social learning, network building, decision-making, negotiation and human capacity building.

8 The '*innovations*' that extension seeks to contribute to are regarded as '*novel patterns of co-ordination and adjustment between people, technical devices and natural phenomena*'. The latter phrase is used to convey that effective innovations – especially in the field of agriculture and resource management – include a balanced mixture of social, technical and natural elements and processes.

9 Extension activities are usually legitimized by referring to the need for solving a *problematic situation*. Whether or not this problematic situation is resolved, and to what extent, is of course something that remains to be seen as the process unfolds. Hence, the use of the term '*supposedly*' in the definition.

10 The term '*supposedly*' is used to point to a different issue as well. Although in an extension process solutions and innovations are often *presented* as contributing to problem solving, this does not mean that they are promoted by extensionists or others solely or mainly for this purpose. In an extension process, change agents may have various aspirations (see also point 6). Thus they may, for example, induce Integrated Pest Management innovations mainly in order to improve their own experience and job opportunities.

11 Finally, the definition mentions '*multi-actor problematic situations*' (rather than of problem situations) in order to indicate that the solving of such situations

> usually depends on the activities of several interconnected actors, who may in fact have different views of what the problem is, and what criteria the solution should meet. Even in situations where an individual farmer raises a seemingly individual problem, there are usually more people involved (e.g. other household members, family, labourers, contractors), who are part of the problem or its solution. For a male farmer, the cost of pest infestation may be a problem because it reduces cash income available for socializing in a bar, while his wife may regard it as a problem because it prevents her from buying school uniforms. Thus, the availability of male and female labour for labour intensive pest management strategies may depend on an agreement on the distribution of the extra cost incurred. Similarly, the feasibility of adopting a disease resistant crop variety – which also happens to be early ripening – may depend on the willingness of others to provide labour at an earlier time in the season.

As can be seen from these discussions, we have tried to arrive at a mainly *descriptive* definition of extension. This is because one cannot hope to contribute to extension without describing what it entails in practice. At the same time, however, it is impossible to make practical contributions without a vision of how it can be done better. Thus, points 3 and 7 are more normative in nature as they indicate what we feel extension *should* do, even if we know that change agents often also use non-communicative strategies to promote change (which contradicts with point 3), and still regard and organize their work largely as 'dissemination' (which is at odds with point 7). We are aware that the descriptive ingredients of the definition in particular may raise additional normative issues for the reader, for example on whether or not we can accept that change agents go against the interests of certain clients, have hidden agendas, personal goals etc.

Terminology from this point onwards

In the preceding sections we have described how the concept of 'extension' has evolved historically, and emphasized the need for a novel definition. Essentially, we intend to look at extension as 'communication for innovation'. From here on we use the latter term whenever possible, or use the term communicative intervention. Similarly, we minimize the use of the terms 'extensionist' and 'extension worker', and – following Van Woerkum et al, 1999 – write of communication specialists, communication workers or change agents instead.

Different Types of Communication Services and Strategies

In practice, communication for innovation can take many forms, not just in terms of the methods and techniques used, but also with regard to the *wider intervention purpose*, which again relates closely to the *assumed nature of the problematic situation*. Depending on the situation, the problem may, for example, be regarded as 'a lack of adequate technology', 'conflict over collective resources', 'lack of organizational capacity' or as 'an individual farm-management problem'. Clearly, the practice of communication for innovation (and the theories on which this is based) will have to differ accordingly. In Table 11.1 we have summarized several types of communicative intervention, which we will call different *communication services* (as a shorthand for 'communication for innovation' services), since they essentially define different kinds of '*products*' that can be 'delivered' by communication workers. At the same time, however, they can be seen as different *communication strategies* because they refer also to the *way in which* communicative intervention is supposed to contribute to societal problem solving. Depending on one's analysis of a problem, one may decide that providing a specific type of *service* is an appropriate *strategy* towards improving the situation.

The first two services in Table 11.1 we group together under the term 'farm management communication'. This involves modes of communicative intervention that are particularly geared towards supporting 'individual' farm households in identifying, interpreting and solving problems on their specific farms. Even if supporting horizontal knowledge exchange clearly involves working with farmer groups, the focus in both types of communicative intervention is on dealing with 'individual' farmers' problem situations ('individual' in quotes because different household members are often involved) which do not require collective action. That is, although farm households can assist each other in managing such issues by means of horizontal knowledge exchange, farm management communication focuses on problems for which the locus of control and responsibility lies with individual farm households, which can take action independently. In contrast, there are several other communication services which inherently require forms of coordination which transcend the household level (see Table 11.1).

Apart from these different communication services/strategies, there are also some general *communication functions* which may be relevant within *each* of the strategies described in Table 11.1. A function like 'information provision' (see Table 11.2), for example, can at some point be relevant to all strategies mentioned in Table 11.1. This implies that even if there are differences with regard to eventual intervention goals, and even if operational methods are likely to be different, there can also be considerable overlap regarding sub-goals and methods.

Together, these services/strategies and functions give an overview of the types of things that communication workers do, and for what purpose. All these services and functions can be performed in different ways, depending among other factors on whether one starts from an 'instrumental' or 'interactive' mindset.

Basic rationale of different communication services and strategies

Communication strategies differ not only in terms of their intervention purpose, but also with regard to the preferred role division between communication workers and clients. Similarly, each distinct strategy requires a different emphasis to the

Table 11.1 *Different communication for innovation services/strategies and their characteristics*

Strategy/service	*Intervention goal*	*Role of communication worker*	*Role of 'client(s)'*	*Key process(es) involved*	*Basis of legitimation*
Focus on 'individual' change/farm management communication					
Advisory communication	• Problem solving • Enhancing problem • Solving ability	• Consultant • Counsellor	• Active problem owner	• Problem solving • Counselling	• Active demand
Supporting horizontal knowledge exchange	• Knowledge exchange • Diffusion of innovations	• Source of experience • Facilitator	• Active learners/ sources of experience	• Learning • Networking • Problem solving	• Active demand • Public interest • Limited resources
Focus on collective change/coordinated action					
Generating (policy and/or technological) innovations	• Building coherent innovations	• Facilitator • Resource person • Supporting vertical knowledge exchange	• Active participants	• Problem solving • Social learning • Network building • Negotiation	• Societal problem solving • Ensuring progress • Qualities of interactive mode of working
Conflict management	• Managing • Pre-existing conflict	• Mediator • Facilitator	• Stakeholder participant	• Negotiation • Social learning	• Wish to remove obstacles to progress
Supporting organization development and capacity building	• Strengthening the position of a group or organization	• Organizer • Trainer • Facilitator	• Active participants	• Social learning • Negotiation	• 'Political' sympathy with a group
Focus can be individual or collective change					
Persuasive transfer of (policy and/or technological) innovations	• Realization of given policy objectives • Predefined behaviour change	• Social engineer	• 'Unexpecting' receiver (initially)	• Adoption • Acceptance	• (Democratic) policy decision • Preceding interactive process

Table 11.2 *General communication functions which can be relevant within different communication services and strategies*

Function	*Intervention sub-goal*	*Role of communication worker*	*Role of 'client(s)'*
Raising awareness and consciousness of predefined issues	• Encouraging people to define a situation as problematic • Mobilizing interest	• Providing (confrontational) feedback • Raising questions	• Unexpecting receiver or relatively passive participant
Exploring views and issues	• Identifying relevant views and issues	• Stimulating people to talk • Active listening • Active learning	• Source of information • Active participant/ learner
Information provision	• Making information accessible to those who search for it	• Translating and structuring information	• Active learner
Training	• Transferring and/or fostering particular knowledge, skills and abilities	• Educator/trainer	• Student

key processes that change agents may usefully support during the interaction. Finally, the grounds on which such services/strategies are, or can be, deemed socially acceptable, desirable and/or legitimate can diverge. It is important that organizations for communicative intervention have a clear idea of the types of services they wish to provide, as it has important implications for the training of staff, recruitment policy, organizational management etc. Below we will outline the basic rationale behind the different communication strategies indicated in Table 11.1.

Advisory communication

Advisory communication happens when farmers ask communication workers to share their ideas on how to deal with a particular management problem. These problems can be immediate and operational (e.g. 'how to fight the disease I discovered yesterday'), or have a longer timescale (e.g. 'what crops can I grow best next year'; 'should I continue farming in the long run'). In helping farmers to deal with such problems, communication workers may not only provide relevant substantive knowledge, but can also offer guidance on the process of problem solving, or can enhance the clients' own problem-solving ability. It can be important to help farmers become more aware of what their goals and aspirations are in the first place (Zuurbier, 1984), so that they can define more clearly what is problematic and what is not.

In principle, the initiative for advisory communication lies largely with the farmer. Of course, communication workers can 'advertise' that they are able to help solve particular types of problems, but it is essentially up to the farmer whether to use such services. It is this active or expected demand by clients that is often used to legitimize the provision of this kind of communication service. In advisory communication, the communication worker's role is basically that of a consultant or counsellor, depending on whether the emphasis is on providing knowledge or process guidance. For the adequate provision of these kinds of services, it is particularly important that communication workers have, or have access to, relevant kinds of expertise, and that they have adequate skills to elicit the needs and expectations of farmers, as well as the capacity to adjust to these.

Supporting horizontal knowledge exchange

Individual farmers usually have much expertise – based on experience, on-farm experimentation and/or training – which could be relevant to other farmers. Farmers are aware of this and as a result there are often informal means of farmer-to-farmer (i.e. horizontal) exchange of knowledge and information. Typically, markets, work parties, funerals, bars, celebrations, community meetings and church services provide opportunities for farmers to talk about agriculture, while observation of other farmers' practices is also an important mechanism for horizontal exchange. If needed, communication workers can stimulate or help to improve farmer-to-farmer exchange in various ways. They can, for example, organize meetings or festivities that are conducive to this kind of exchange, induce the formation of study groups, support existing groups and networks with training and logistics, develop more systematic modes of farm comparison, correct uneven exchange of knowledge within communities, communicate experiences from other communities, organize excursions etc. The role of the communication worker here is not that of a consultant or expert, but rather of a *facilitator*; that is, of someone who brings people together (networking) and acts as a catalyst for, and/or directs, learning and exchange processes, either in general or around a specific problem. Sometimes farmers actively demand these kinds of services, while in other cases governments support farmer-to-farmer exchange for the benefit of the public (e.g. more rapid diffusion of innovations). In addition, public extension organizations in particular often use farmer-to-farmer exchange to make efficient use of increasingly limited resources, i.e. to reach a relatively high number of farmers with limited inputs and/or to stimulate knowledge exchange in the absence of professional communication workers.

Generating policy and/or technological innovations

As indicated in the previous chapter, there is an increased need for communication workers to organize processes through which new innovations are designed, rather than to 'sell' predefined packages to farmers. 'Innovations' here are 'novel working wholes' (Roep, 2000) that involve a variety of practices and multiple actors. Often innovations have technological components, but some are more 'policy-oriented' such as novel market arrangements, new government regulations and/or alternative forms of organization. The main purpose of this type of communication service, then, is to arrive at appropriate and coherent innovations in the face of certain challenges and/or problems. Due to the collective nature of innovations, this communication service usually requires the bringing together of various stakeholders in group sessions and/or semi-permanent 'platforms' (Röling, 1994a). Here a wide range of activities can take place, including joint experimentation and exploration, aimed at generating new knowledge, insight and mutual understanding. In addition, forging effective links and knowledge exchange between such platforms and various knowledge institutions (e.g. applied research, universities etc.) can be an important stimulant to innovation. Again, the key function for communication workers here is to facilitate the process, and it is important to work towards a balance between new *technical* devices and novel *social-organizational* arrangements. Thus, besides learning-oriented activities such as experimentation and exploration, sufficient attention should be paid to the creation of support networks and the negotiation of new arrangements between various stakeholders. This often means that communication workers have to deal with tensions and conflicts that emerge during the innovation process. Investments in these kinds of innovation processes are often made because of specific societal problems and/or the desire to foster progress in areas where this is thought to be lacking. Moreover, this type of communicative intervention is inherently interactive (at least to some extent) and is frequently legitimized with reference to specific qualities attributed to an interactive mode of working.

Conflict management

In some situations, serious tensions and conflicts among stakeholders form the starting point for communicative interventions, rather than the intervention emerging during an interactive process (see above).[1] In many communities or regions conflicts exist around the distribution and use of collective resources (e.g. water, arable land, grazing land, fish etc.). Such conflicts often have cultural, ethnic, moral and/or political dimensions too. In some cases conflicts are productive in the sense that innovative solutions arise from the pressures and competition that accompany conflict. All too frequently, however, conflicts have negative consequences (e.g. natural resource degradation) and/or hinder progress and innovation; that is, in some cases it can be a long time before conflicts are resolved and/or become productive. Communication workers are often confronted with conflicts that affect their work and they can even become entangled in them. From the literature on conflict resolution (e.g. Pruitt and Carnevale, 1993), however, we know that the involvement of relative outsiders – in the form of mediators, facilitators or referees (e.g. judges) – may help to partly resolve conflict and/or to make conflicts productive. Thus, rather than becoming a party in the conflict, communication workers may at times be able to play a positive role in conflict management. Depending on the situation, this can be either by adopting a mediating or facilitating role, or by encouraging the handling of the conflict by others who are in a better position – in terms of status, skills and authority – to contribute positively. As Röling (1994a, 1994b) suggests, such efforts may take place on a 'platform' where different stakeholders are brought together to overlook the situation and learn and negotiate towards more productive outcomes (i.e. coordinated action). Although conflict management has not been a traditional extension service or strategy, we feel that 'new style' extension organizations may have to become better equipped for it. This is because innovation, conflict and intervention are closely intertwined, which essentially means that conflict management is something that change agents cannot run away from. Dealing with tension and conflict requires insights and skills that, in our experience, are not yet widely available in public or private organizations that apply communicative intervention.

Supporting organization development and capacity building

In many cases innovation involves and/or depends on the adequate functioning of farmer and community organizations or groups, such as irrigation management committees, credit groups, marketing cooperatives, commodity groups, study groups etc. For purposes of conflict resolution it can be important too that weaker parties become better organized and improve their ability to make claims. Thus, an important role for communication workers can be to contribute to organization development and human capacity building, so as to strengthen a particular group's capacity to innovate, help themselves and/or make claims. The role of change agents here can range from initiating organization development, contributing to organizational activities and processes, providing training in organizational skills, facilitating processes of organization change etc. Such activities are often inspired by 'political' sympathy with particular, often disadvantaged, groups. The term 'political' here does not refer to political parties or movements, but rather to the fact that 'strengthening a group' means almost automatically to improve their 'power position' with regard to others.

Persuasive transfer of policy and/or technological innovations

The most widespread form of communicative intervention is to persuade farmers or other target groups to adopt specific technological packages and/or to accept certain ideas or policies. The main intervention goal here is to help realize specific policy objectives (e.g. increase export earnings) by the stimulation of predefined behaviour changes (e.g. the adoption of cash crops and/or new varieties). Typically, such efforts have been in the form of comprehensive extension campaigns, which in their eventual form and method partly resembled what we have called 'advisory communication' and 'horizontal knowledge exchange'. However, whenever external[2] persuasive concerns enter an interaction between communication workers and farmers, we would prefer to call it '*persuasive transfer*' rather than 'advisory communication' or 'horizontal exchange' – even if the form may be the same – because it means that a different intervention goal and operational logic enters the scene. As part of this logic, the required role of the communication worker in persuasive transfer is much more that of a social engineer who tries to manipulate strategically the farmers' behaviour, rather than that of a consultant or facilitator. Similarly, the role of the client is different in persuasive forms of communicative intervention. Usually people do not ask to be persuaded in a specific direction, so farmers are more at the receiving end than the demanding end. Although persuasive transfer has become increasingly unpopular in discussions of communicative intervention, persuasive transfer of innovations still exists widely. Often this form of intervention is based on local or national policy decisions (e.g. to increase cotton production, or reduce the use of pesticides), or an earlier interactive process in which stakeholders agreed on the promotion of certain behaviour changes.

In this section we have tried to unravel different types of communication services and strategies, distinguished mainly on the basis of their underlying intervention goal and not on the basis of their method. In practice, several intervention goals can play a role within particular activities, in which case the distinction is more analytical than practical. In other cases these types of services can be associated with specific activities. In any case, the distinction is important in that it may help communication workers and their organizations to think about what their mission and mandate is or should be.

Agricultural Knowledge Systems and Other Extension-related Concepts

The term 'agricultural extension' refers not only to a professional practice, but also to an area of study which has generated knowledge and insight and can be studied in agricultural colleges and universities. In this section we clarify several terms used in connection with this, and also propose alternative terms in view of our wish to move away from the concept of 'extension'.

Agricultural knowledge systems

Conventional extension organizations have always been looked upon as playing a role among other institutions, functions and actors who are active in the area of agricultural knowledge, such as universities, strategic research, stations for applied research, farmers, agribusiness, agricultural magazines, agricultural schools and colleges etc. This collection of actors is often referred to as the agricultural knowledge and information system (AKIS) (Röling, 1989; Engel, 1995; FAO and World Bank, 2000). For a long time the role of extension and communicative intervention was looked on as transferring and disseminating ready-made knowledge from research to farmers, or from 'early adopters' to other farmers. This is often referred to as the 'transfer-of-technology' model of extension (Chambers et al, 1989), which fits in with a linear model of innovation. As shown earlier in this chapter, we now look at the role of communicative intervention in a much broader way. The emphasis is much more on the facilitation of network building, social learning and conflict management among a variety of actors with a view to arriving at new innovations. Thus, communication workers are seen as interacting with a wider set of actors than the knowledge institutions. Nevertheless, it remains relevant to look at issues like knowledge exchange and links between clients, extensionists, research and other parties in the agricultural knowledge system; not least since other knowledge institutions may well have an influence on whether or not communication workers can effectively play their newly envisaged roles. Communication workers might, for example, aspire to engage in interactive technology design, but find out that research institutes are unable or unwilling to cooperate and coordinate activities to that end. Thus, when talking about agricultural knowledge systems, one is immediately confronted with issues of interinstitutional cooperation and associated problems.

In order to understand the functioning and potential of communicative intervention, it remains vital to look at it in the context of other actors in the knowledge system.

Extension science/communication and innovation studies

In agricultural universities, groups have emerged that study the phenomenon of 'agricultural extension', as described by its evolving definitions (see 'Historical roots and evolving conceptions of extension'). Röling (1988) has called this academic tradition 'extension science', and new names are being invented to describe this field of study. In The Netherlands we now speak about 'Communication and Innovation Studies'. Scholars in this field systematically investigate communication for innovation processes and experiences, and connect their conclusions with more abstract and general concepts and theories. In the early days extension science was predominantly an applied science in that most of the questions and conclusions were aimed at informing communication workers how to do a better job. Thus, many theories were formulated on, for example, how to use media effectively, how to develop effective communication plans, how to manage agricultural knowledge systems. More recently, studies have appeared which are more oriented towards describing and interpreting what happens around communication for innovation processes, and which do not start from a wish to arrive at practical, prescriptive theories and recommendations. One can, for example, analyse how communication workers cope with the contradictory pressures from farmers and the government, without wishing to inform them on how to do so better. But such studies can usually be used by others to derive valuable practical lessons. Typically, communication and innovation studies borrows insights from, and sometimes adds insights to, several other social science disciplines. Originally, these were mainly communication science, social psychology, adult education and rural sociology. More recently, many more disciplines have offered inspiration to our field of study, including the sociology of science and technology, management science, systems theory, political science and anthropology.

Although communication and innovation studies is a *social* science field, it has also attracted interest from natural scientists, not least because it often focuses on those interactions between people that concern their agroecological environment. This meeting of social and natural scientists' views is partly what makes our field of study so interesting, but it also generates tensions since social scientists and natural scientists often have very different ideas about the role and potential of scientific knowledge. Apart from this, social scientists and natural scientists tend to face rather different methodological challenges, and thus tend to work in very different ways. Thus, when natural scientists start to get involved in communication and innovation studies it often takes them a while to adjust.

Extension training/communication for innovation training

Conventionally, the term 'extension training' referred to the process through which extension staff became equipped to do their job. This kind of training has also been referred to as 'extension education'. However, in view of the strong educational connotations in early definitions of extension, this latter term has also been used synonymously with extension practice itself (e.g. Supe, 1983). In any case, we now prefer the term 'communication for innovation training'. Such training provides change agents at different levels in organizations (management, field workers etc.) with insights and experiences for taking strategic and operational decisions in communicative intervention. It may cover technical, methodical and/or management issues, and it can take place in various ways; for example through formal courses, fixed or flexible curricula, practicals, supervision, distance education, workshops and organization development trajectories.

Ideally, the findings from communication and innovation studies offer inspiration to those who perform communication for innovation training. Thus, we hope that trainers can pick out elements of this book, connect these with other experiences, and translate the resulting mix of insights into training modules for communication workers.

Extension research/communication for innovation research

We can distinguish two types of extension, or communication for innovation, research. First, as an integral part of communication for innovation activities, change agents regularly need to engage in investigation and research, such as situation analysis, exploration, literature research, on-farm research, pretesting, monitoring and evaluation. Typically, such research is 'decision oriented' in that it helps communication workers and others to make decisions about the nature and content of their future activities. We refer to this kind of activity as '*decision-oriented research*', which is part of an intervention process. In order to yield useable results, this kind of research cannot be a detached activity carried out by an isolated investigator. Rather, considerable interaction with prospective clients is needed to make sure that the decisions taken are in line with their needs and requirements.

Earlier we touched on a second type of research, which is usually carried out by scholars in communication and innovation studies (or extension science; see above). Although in some cases their research may overlap with decision-oriented research, academics usually have an additional interest, which is to conceptualize and theorize about the findings. In other cases, this kind of '*conceptual research*' has little connection with decision-oriented research. It may, for example, involve social psychological experiments in a laboratory setting, or may be oriented merely towards observing the communicative intervention arena, with no intention to directly inform decision making by communication professionals. As we have discussed under the heading of extension science, conceptual research is still often applied research since it frequently seeks to develop or test theories that have practical or even prescriptive implications for communication workers. Thus, the main difference between decision-oriented and conceptual research lies in the level of abstraction and the intention of the researcher, and not so much in its applicability. As Kurt Lewin stated: 'There is nothing so practical as a good theory'. Given its theoretical aspirations, however, conceptual research will often have to meet different (i.e. academic) standards, in terms of preparation, methodology and analysis, from those of decision-oriented research.

Notes

1 Note that in some cases such conflicts are in part the result of previous interventions by others or one's own organization.

2 By 'external' we mean persuasive interests that derive from donors or governments who play a role in the 'back of the mind' of the communication worker. This is in contrast to a situation where a change agent presents advice persuasively to emphasize that he really ('internally') believes that it is in the best interest of the – perhaps even paying – farmer to solve a problem in a particular way.

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12

Use of Communication Media in Changing Rice Farmers' Pest Management in the Mekong Delta, Vietnam

K. L. Heong, M. M. Escalada, N. H. Huan and V. Mai

Introduction

Pesticides have dominated pest management practices of rice farmers for the past 30 years. The agrochemical era of the 1960s and 1970s that had strongly influenced chemical oriented agricultural research and extension in the United States (Rossiter, 1975) is still having a dominant effect in many developing countries. Most Asian rice farmers have adopted pesticides as their main pest control tactic (Heong and Escalada, 1997b) using insecticides more frequently than herbicides and fungicides in most countries. In many cases, these insecticide applications are unnecessary and are unlikely to result in an economic return. In the Philippines, for example, about 80 per cent of insecticide sprays were misused because they were applied at the wrong time and on the wrong targets (Heong et al, 1995a). Farmers targeted most insecticides at leaf-feeding insects in the early growth stages (Heong et al, 1994; Mai et al, 1997). The most common species is the rice leaf folder (*Cnaphalocrocis medinalis* Guenee), which causes highly visible damage symptoms. Farmers generally perceive that the damage due to these pests (often referred to as 'worms') reduces yield so they apply insecticides (often referred to as 'medicine'). The less expensive and highly toxic chemicals, such as methyl parathion, monocrotophos and methamidophos, are frequently used.

However, research has shown that the common leaf-feeding insects, such the leaf folder, whorl maggot (*Hydriella philippinensis*) and army worms (like *Spodoptera litura*) that often attack the rice crop during the vegetative stages arc rarely in sufficiently high densities to reduce yield. Even when all hills were damaged by whorl maggots, no yield loss could be detected (Viajante and Heinrichs, 1986;

Shepard et al, 1990). For leaf folders, a larva could consume about 25cm^2 or less than 40 per cent of a normal leaf of *indica* rice (Heong, 1990). Incorporating this feeding rate, the rice model, MACROS, predicted that yield would decrease when the larval density reached 15 per hill (Fabellar et al, 1994), but normal larval densities are usually well below three per hill (Gou, 1990; de Kraker, 1996), mainly because of natural biological control. Thus, in most cases, insecticides applied into rice fields during the early crop stages to control leaf folders are unlikely to benefit farmers economically. Instead, they can cause ecological disruptions to the herbivore–predator relationships by shortening the mean food web chain length, favouring an increase in the population of some [herbivorous species, for example, delphacids, and causing secondary brown plant hopper pest problems (Way and Heong, 1994; Heong and Schoenly, 1998).

Farmers' insecticide use decisions do not seem to be based on economic rationale (Lim and Heong, 1984; Waibel, 1986; Rola and Pingali, 1993; Heong and Escalada, 1997a). These decisions, often made under uncertainty, are influenced more by perceptions of the pest and benefits from spraying. When decisions are made under uncertainty, people often use decision rules (Einhorn and Hogarth, 1981; Eiser, 1986; Payne et al, 1992). The term, heuristic, was introduced by Kahneman and Tversky (1973) to refer to an informal rule-of-thumb used by people in order to simplify information processing and decision making. Heuristics are developed through experience and guesswork about possible outcomes and may have inherent faults and biases (Tversky and Kahnemann, 1974; Slovic et al, 1977). Farmers' reaction to damage by leaf–feeding insects by spraying insecticides may well be due to faults in their beliefs or the heuristics that they use (Bentley, 1989). Heong and Escalada (1997a) applied the cognitive dissonance theory (Festinger, 1957) to motivate farmers to evaluate whether information expressed as a heuristic: 'Insecticide applications in the first 30 days after transplanting (or 40 days after sowing) for leaf folder control is not necessary.' After the experiments most farmers changed their perceptions. Similar farmer participatory evaluations conducted in the Mekong Delta had the same effects on farmer perceptions and practices (Heong et al, 1995b).

It has been common practice for farmers to spray the early crop stages (Heong et al, 1994; Mai et al, 1997) to control leaf folders and other defoliators. Using a 15-week season-long training programme, the Farmer Field Schools (FFS) in Indonesia significantly reduced the use of insecticides by trained farmers (Useem et al, 1992; Matteson et al, 1994; Rombach and Gallagher, 1994). Since its introduction in 1989, perhaps 2 million of Asia's more than 200 million rice farmers have attended FFS and presumably have acquired sufficient decision making skills to apply insecticides rationally. The task and related costs and time necessary to reach the remaining 99 per cent of Asia's rice farmers are thus enormous.

Extension media to communicate pest management messages has been successfully implemented in Asia (Escalada and Kenmore, 1988; Pfuhl, 1988; Adhikarya, 1994; Ho, 1996). Traditional media, such as folk songs, drama and puppet shows can also be effective (Van de Fliert and Matteson, 1990; Stone, 1992). The rat control campaign in Malaysia increased farmers' adoption of chronic poison baits from 61 to 98 per cent and physical control methods from 31 to 60 per cent (Matteson et al, 1994). In the weed management campaign in Malaysia, farmers' herbicide use, although initially increasing (Matteson et al, 1994), resulted in a 50 per cent reduction four years after the campaign was launched (Adhikarya, 1994; Ho, 1996), a phenomenon known as the 'sleeper effect' (Schramm, 1973). Such marketing strategies have also been successfully used in improving health care practices, accelerating adoption of family planning and reducing cigarette smoking and in changing attitudes towards drug abuse (Rice and Paisley, 1981; Manoff, 1985; Kotler and Roberto, 1989).

As the mass media have been proven to be the most rapid and efficient means for diffusion of innovation (Rogers, 1995), rice farmers' beliefs, attitudes and practices in spraying against leaf-feeding insects presented an opportunity for us to evaluate the use of communication media to motivate farmers. The innovation was presented as a conflict information, and farmers were motivated to evaluate it. In this paper, we report the effects of a media campaign on farmers' perceptions and practices related to pest management in general and leaf folder control in particular.

Methods

Study sites

The study sites were two districts in the province of Long An situated in the Mekong Delta in the southern part of Viet Nam. Tan Tru district covers a total of 10,200km^2, whereas the Tan Thanh district covers 42,600km^2. Agriculture is the main economic activity in these two districts, with rice as the principal crop. In addition, watermelon, ground nuts, vegetable and other cash crops are cultivated. Most farmers grow two rice crops a year, whereas some grow three. The two study sites produce a total of 244,000 tons of rice per annum, about 20 per cent of the province's production of 1.2 million tons. The total number of farmer households in Tan Tru is about 11,000 and in Tan Thanh, about 10,000, accounting for 10 per cent of the province's farmer population of 210,000 (Cuc, 1995).

Planning workshop

A workshop with participants from research, extension and agricultural communications was conducted in Vietnam to develop media materials that will motivate farmers to evaluate the heuristic: 'Spraying insecticides for leaf folder control in the first 40 days after sowing is not needed.' In the three-day workshop, several versions of a leaflet, a poster and a radio drama, were developed [see Rapusas et al (1994) for a full report]. These materials were designed to provide both the information (What is the innovation?) and the innovation-evaluation information (What are the consequences of the innovation?). They were pretested in the sites with groups of farmers, and from the feedback, final versions of the three media were mass produced. A distribution plan was developed by the campaign management committee, headed by the Vice Chairperson of the Peoples' Committee of the province of Long An, and on 8 September 1994, the campaign was launched by the Vice Minister of Agriculture in a ceremony where a few selected fanners who had carried out the evaluation [see Heong et al (1995b)] presented their findings.

Material distribution

A total of 21,000 leaflets were distributed to all households in the two districts through the district Plant Protection offices. Four thousand posters were posted in village billboards, coffee shops, supply shops, government offices and markets. On the leaflets and posters, a message to encourage farmers to contact the Plant Protection Department to learn more about IPM concepts was also included. The drama entitled 'Well, I shall try', depicted a conversation between a farmer who had conducted the evaluation encouraging another farmer to try it (script in Appendix). Three local actors were employed to produce the drama, recorded in 40 cassette tapes that were distributed to radio stations for broadcasting twice a week during the crop season (September 1994 to January 1995) and to coffee shops to be played over their audio systems. In addition, the Long An provincial government built nine billboards measuring 3 × 2m that were placed along the main roads and market places. Vehicles with public address systems and posters were also used. Distribution of the materials was monitored through a management monitoring survey conducted in November 1994.

Data collection

The research design used was the pretest–post-test design (Campbell and Stanley, 1973; Neuman, 1991), which involved a pretest, the intervention, a monitoring survey and three post-tests. We used quantitative research methods for data gathering and qualitative methods to complement the data, in all surveys. The qualitative methods that we used included non-structured conversations with farmers that provided opportunities for probing into individual farmers' responses, focus group interviews to obtain group consensus in responses and participatory observations. In addition, supplementary data on pesticide sales, prices and farmer training activities over the research period were obtained from the provincial agricultural office.

Five evaluation surveys were used, the pretest, the management monitoring survey, the post-test in February 1996, 18 months after introduction, the post-test in March 1997, 31 months after introduction and the post-test of farmers in the other 12 districts in Long An province conducted in September 1996. The variables and questions used in each survey were determined by conducting a conversational analysis in an exploratory field research carried out by the authors. Each questionnaire was then developed, translated into Vietnamese and pretested with 20–30 respondents. Ambiguous questions were modified to ensure clarity and further pretested, if necessary. In order to capture farmers' direct responses, we used open-ended questions wherever possible. The surveys were administered by students from the local agricultural institute. The provincial agricultural technicians supervised the operations but had no input in administering the questionnaires. For each survey, a training course, which included a practice session, for all involved in the survey was conducted by the authors to ensure quality and consistency. The student interviewers were trained to record the exact words farmers used in response to each question. We supervised each survey, and the field data obtained were immediately coded and entered into the computer using a spreadsheet program. Whenever errors in data entry were encountered, they were referred back for clarification. We also conducted quality assurance checks when the surveys were being conducted. Each survey was administered within a week.

The pretest survey, conducted in August 1994, collected data on farmer profiles, pest management knowledge, perceptions, attitudes and practice from a sample of 633 randomly selected respondents in the two districts. Details of the survey are reported in Mai et al (1997). A management monitoring survey was conducted in November 1994 with a sample of 2226 randomly selected farmers, to monitor the distribution and reach of the media materials. The first post-test survey was conducted in February 1996 with a sample of 452 randomly selected farmers. In this survey, besides monitoring the same variables as in the pretest survey, we added seven perception questions. In March 1997, we conducted the second post-test survey using the same instrument with a sample of 628 randomly selected farmers. To monitor diffusion of the innovation to other districts in the province, a survey of 1449 randomly selected farmers from the other 12 districts in Long An province was conducted in September 1996.

Analytical methods

The field data were coded and entered into a spreadsheet program. Frequency distributions and cross-tabulations were generated by using Statistical Analysis Systems (SAS, 1985) and Statistical Package for Social Sciences for Windows 7.5 (SPSS, 1997). Means were compared using *t*-test procedures, and both parametric and non-parametric statistics were used for correlation and testing of variables.

Belief index

Farmers' beliefs were measured through the use of five statements to which respondents were asked to state whether they agreed, disagreed with them or were indifferent. A three-point Likert scale (1 for the preferred answer, 2 for indifference and 3 for the not preferred) was used to score responses. The three statements used to assess the components of belief about leaf folders were: 'Leaf folders in the first 40 days after sowing (DAS) can cause severe damages to the crop'; 'Leaf folders in the first 40 DAS will cause yield loss'; and 'Spraying in the first 40 DAS to control leaf folders is necessary'. Two other statements were related to general insecticide use: 'Applying insecticides will increase yields' and 'Killing natural enemies by insecticide spraying will not cause more pest problems'. The belief index for each respondent was computed by summing across the scale ratings and statistically compared. The questions were framed in such a way that the bipolar points of the index would be 5 and 15 (5 means that all the statements were the preferred answers, and 15 means that all the statements were not preferred).

In the three follow-up post-tests, an additional seven belief statements were used (Table 12.5), and farmers were asked to respond whether they disagreed, were indifferent or agreed with the statements.

Results

Profiles of rice farmer respondents

Profiles of farmer respondents in the pretest, the three post-test surveys in the study sites, Tan Tru and Tan Thanh and the post-test in the remaining 12 districts are summarized in Table 12.1. Most farmers interviewed were between the ages of 31 and 50 with an education of between 1 and 9 years. Only a small proportion (<8 per cent) had not attended school. Farm sizes were generally less than 1ha, and the yields reported varied between 3 and 5 tons ha^{-1}.

Farmer access to communication media

From the pre-test survey, about 66 per cent of the farmers interviewed said that they owned a radio. Farmers in the two districts generally listened to two radio stations, Radio Ho Chi Minh (49 per cent) and the Long An provincial station (46 per cent). These two stations were used to broadcast the mini drama. The preferred times for broadcasts were 5.00–8.00 am (40 per cent), 6.00–8.00 pm (29 per cent) and 12.00–2.00 pm (16 per cent). Farmers said that they preferred programmes with farming information (46 per cent), news (17 per cent) and drama (16 per cent). Among the printed materials farmers frequently read were newspapers (47 per cent), leaflets (37 per cent) and magazines (8 per cent). About 44 per cent of the respondents owned a television and the most common stations that they had access to were TV Ho Chi Minh and TV Can Tho.

Delivery and reach of media materials

In the management monitoring survey conducted two months after the materials were distributed, 97 per cent of the farmers interviewed were aware of the campaign. The most commonly cited source farmers heard from was the leaflet (89 per cent), followed by the radio drama (72 per cent), poster (69 per cent), the demonstration plots (43 per cent), friends (34 per cent) and the billboards (34 per cent). Most of the leaflets were delivered to the households (96 per cent). The radio

Table 12.1 *Profiles of the randomly selected farmer respondents in the surveys in Long An*

	In project sites, Tan Tru and Tan Thanh (%)			
	pretest	*post-test*		
	August 1994 $n = 633$	*February 1996* $n = 452$	*March 1997* $n = 628$	*In 12 districts* $n = 1449$
Age group (years)				
< 31	14.8	16.5	17.4	12.7
31–40	35.1	27.3	33.7	32.2
41–50	19.8	25.1	24.1	28.6
51–60	15.1	16.9	13.3	17.0
61–70	12.1	11.3	7.7	8.4
> 70	3.2	3.2	3.8	1.1
Education (number of years in school)				
Did not attend school	5.9	5.3	7.7	6.3
1–5	54.7	45.3	45.9	31.3
6–9	25.8	31.8	38.6	40.0
10–12	13.3	17.6	12.8	22.3
> 12	0.3	0	0	0.1
Farm sizes (ha)				
< 0.5	31.8	25.6	24.8	32.7
0.6–1	30.0	31.8	29.5	30.5
1.1–2	25.9	24.2	23.9	19.3
2.1–3	8.4	10.0	12.0	7.5
3.1–4	1.4	4.4	4.5	3.5
> 4	2.5	4.0	5.3	6.5
Yields ($t\ ha^{-1}$) reported				
< 2	15.5	6.7	5.9	4.6
2.1–3	26.7	11.1	17.7	9.7
3.1–4	34.7	25.8	33.5	21.1
4.1–5	18.2	28.0	26.4	29.2
> 5	4.7	28.5	16.5	35.5

drama was heard over radio Ho Chi Minh (76 per cent) and provincial radio (22 per cent), whereas the posters that were displayed in buildings along the road were most frequently observed (60 per cent), followed by those in the coffee shops (16 per cent), market (5 per cent), schools (4 per cent) and friends' houses (3 per cent).

What farmers learnt from the media materials

In the post-test, we used an open-ended question to assess what farmers learnt from the three media materials. Farmers learnt that there was no need for insecticide spraying against the leaf folder in the first 40 DAS (69 per cent), that avoiding the use of insecticide during this period saves money and labour (30 per cent), that spraying early in the season is detrimental to natural enemies (20 per cent), how to conduct an experiment (14 per cent), that leaf folder damage during the early growth stages do not reduce yields as crops recover (11 per cent), that insecticide spraying can be detrimental to one's health (13 per cent) and that insecticides pollutes environment (6 per cent). When they obtained the information from the media, about 56 per cent of the farmers said that they conducted the experiment, 15 per cent said that they stopped spraying for leaf folders in the first 40 DAS, and 15 per cent said that they did not do anything about it. The main reasons provided for not responding were that they were worried about pest attacks when they did not spray (34 per cent), afraid of yield loss (19 per cent), did not believe in the message content (11 per cent), had no time to experiment (8 per cent) and about 6 per cent did not understand the information.

Changes in farmers' insecticide use patterns

Changes in farmers' insecticide use over the 31-month period are shown in Table 12.2 and Figure 12.1. The mean number of sprays that farmers applied declined from 3.35 per farmer to 1.56 18 months after distribution. There was a slight increase to 1.76, although not significant, a year later. The mean number of insecticide sprays by farmers in the 12 districts outside the study sites in 1996 was 1.58, which was not significantly different from the study sites. The proportion of farmers who

Table 12.2 *Changes in farmers' insecticide use*

	In study sites, Tan Tru and Tan Thanh			
	Pretest	*Post-tests*		
	August 1994	*February 1996*	*March 1997*	*In 12 districts*
Number of farmers interviewed	633	452	628	1449
Total number of insecticide sprays applied	2123	700	1103	2286
Mean number per farmer	3.35	1.56	1.76	1.58
SD	1.75	1.20	1.35	1.26
Range	0–11	0–8	0–9	0–10
Percentage of farmers not using insecticides	1.1	20.2	31.7	20.4

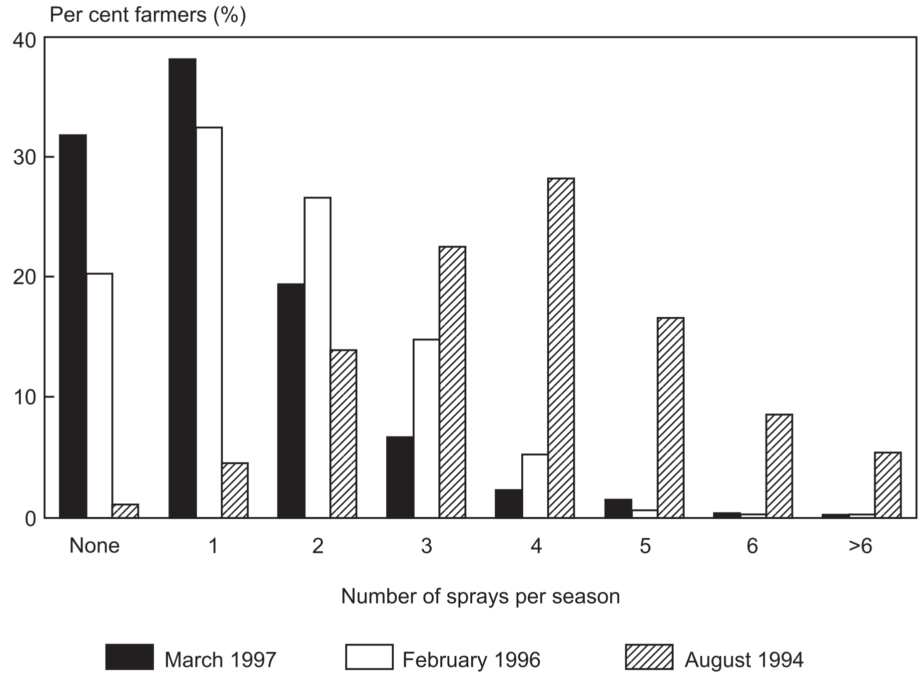

Figure 12.1 *Changes in rice farmer's insecticide spray frequencies in Tan Tru and Tan Thanh districts, Long An province, in August 1994 just before the introduction, 18 months after in February 1996 and 31 months after in March 1997*

did not use any insecticides increased from 1 per cent in pretest to 20 per cent in the first post-test and to 32 per cent in the second post-test. In the 12 districts, 20 per cent of the farmers interviewed did not apply any insecticides. The insecticide spray frequency distributions significantly shifted to the left with more farmers applying only once or twice after the introduction of the media materials (Figure 12.1). The proportion of farmers spraying during the early tillering, late tillering and booting stages declined significantly (Friedman test chi-square = 7.6, $P < 0.05$) (Figure 12.2). In the pretest, 59 per cent and 84 per cent of the farmers sprayed during the early and late tillering stages, respectively. In the first post-test, the proportion of farmers spraying in the early and late tillering stages dropped to 28 per cent and 42 per cent, respectively, and in the second post-test, these proportions further declined to 0.2 per cent and 19 per cent, respectively. In the 12 districts, 13 per cent of the farmers sprayed during the early and 24 per cent in the late tillering stages. The proportion of farmers spraying in the reproductive and maturing stages initially declined in the first post-test but increased in the second post-test, but were still lower than that in the pretest.

Although the number of insecticide sprays was reduced over the period, farmers' spray targets had not significantly changed (Friedman test chi-square = 0.33, $P > 0.05$). The rice leaf folder and other leaf-feeding insects remained the main targets,

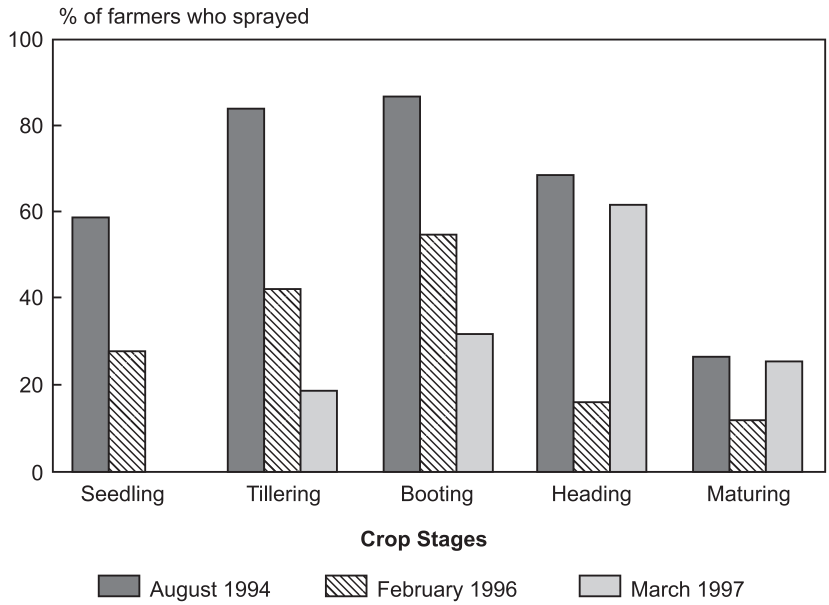

Figure 12.2 *Rice farmers' insecticide applications in different crop stages in Tan Tru and Tan Thanh districts, Long An province, in August 1994 just before the introduction of the media materials, 18 months after in February 1996 and 31 months after in March 1997*

accounting for 44 per cent, 52 per cent and 53 per cent of farmers' applications in the 1994 pretest, 1996 post-test and 1997 post-test, respectively (Table 12.3). Farmers' targets in the 12 districts were also the same, with 40 per cent of the sprays used for rice leaf folder control. The types of insecticides and farmers' belief that insecticides can be harmful to health (Table 12.5) have also remained relatively unchanged. Methamidophos, monocrotophos and methyl parathion [all

Table 12.3 *The main pest targets of farmers' insecticide sprays*

	Percentage of sprays			
	In study sites, Tan Tru and Tan Thanh			
	pretest	*post-test*		
Targets	*August 1994*	*February 1996*	*March 1997*	*In 12 districts*
Rice leaf folders	33.4	37.0	43.8	39.5
Other leaf feeding insects	10.2	14.7	9.0	12.1
Stem borers	10.1	25.9	8.0	22.4
Thrips	14.0	6.1	8.5	5.5
Brown plant hoppers	28.0	7.6	12.4	11.5
Others	43	8.7	8.3	9.0

Table 12.4 *Main insecticides (in percentage of sprays) of rice farmers in Long An Province*

	WHO classification	In study sites, Tan Tru and Tan Thanh			
		pretest	post-test		
		August 1994	February 1996	March 1997	In 12 districts
Organophosphates					
Monocrotophos	1b	6.8	9.7	6.1	4.2
Diazinon	1l	1.6	5.6	1.1	9.2
Methyl parathion	la	12.1	7.2	3.4	3.4
Methamidophos	1b	28.9	31.1	31.4	25.0
Organochlorines					
Lindane	1l	0.0	0.3	0.2	0.5
Endosulfan	1l	4.0	0.5	0.1	2.5
Carbamates					
BPMC (fenocarb)	1l	16.5	9.5	9.6	10.1
MIPC (isoprocarb)	1l	2.7	0.0	1.6	0.0
Carbofuran	1h	0.1	0.2	1.1	0.4
Pyrethroids					
Cypermethrin	1l	0.1	1.8	7.8	5.7
Dehamethrin	1l	5.7	6.1	8.8	2.8
Lambda cyhalothrin	–	2.9	9.0	8.7	9.8
Others					
Cartap	–	0.0	10.0	7.4	10.7
Buprofezin	V	7.8	2.6	5.1	2.5

WHO category I pesticides (CIRAD, 1991)] accounted for 48 per cent of the sprays in the 1994 pretest and 1996 post-test (Table 12.4). In the 12 districts outside the study sites, these three WHO category I insecticides constituted 33 per cent of the sprays used.

Changes in farmers' beliefs

The belief index reduced significantly from 11.25 (±0.18 at 95 per cent CL) in the 1994 pretest to 8.22 (±0.27 at 95 per cent CL) in the 1996 post-test and 7.62 (±0.24 at 95 per cent CL) in the 1997 post-test. The higher belief index in the pretest meant that more farmers had non-preferred beliefs. In the 12 districts, the belief index was found to be 8.11 (±0.85 at 95 per cent CL). Table 12.5 shows changes in farmers' beliefs in the three statements related to the rice leaf folder problem to the two statements relating to insecticide use. Except for the statement

Table 12.5 *Comparison of responses to belief statements by farmers of Tan Tru and Tan Thanh districts pretest in 1994, post-tests in 1996 and 1997, and farmers of the other 12 districts in Long An province*

	Percentage of farmers who agreed to the statements			
	pretest	*post-tests*		
	1994	*1996*	*1997*	*12 districts*
Applying insecticides will increase yields	39.0	35.6	29.7[a]	32.0
Insecticides will harm natural enemies	–	87.3	82.1[b]	86.5[a]
Killing natural enemies can cause more pest problems	27.2[c]	52.9	68.3[a]	58.9[a]
Spraying insecticides can harm human health	–	96.7	97.5	97.2
Spraying insecticides contaminates the environment	–	63.5	78.0[a]	80.7[a]
Applying insecticides in the first 40 DAS is a waste	–	81.3	88.9[a]	79.5[a]
Applying insecticides in the first 40 DAS can cause more pests	–	70.9	74.9[b]	69.6[a]
Leaf folders in the first 40 DAS can cause severe damage	66.1[c]	27.2	24.0	25.7[a]
Leaf folders in the first 40 DAS will cause yield loss	69.8[c]	26.2	24.8	26.1[b]
Spraying in the first 40 DAS for leaf folder control is necessary	–	31.0	24.8[b]	27.0[a]
Spraying insecticides for leaf folders has to be done in early season	77.2[c]	21.6	23.2	25.3
Rice crops can recover from early-season leaf damages by pests	–	86.9	92.2[b]	83.2[a]

Critical values of chi-square tests at d.f. = 2, $P = 0.05$. 5.99 and $P \approx 0.01$. 9.21.

[a,b] Significant differences at $P = 0.01$ and $P = 0.05$ probability levels, respectively, from post-test 1996.

[c] Significant differences at $P = 0.01$ probability levels, respectively, between pretest (1994) and post-test (1996).

'Applying insecticides will increase yields', farmer responses to the four other statements were significantly changed. In the 12 districts, similar farmer responses were obtained (Table 12.5), implying that although the campaign was launched in the study sites, it had significantly influenced farmers in other districts quite distant from the sites. In the 1997 post-test, responses to the seven additional belief statements were significantly different from that of the 1996 post-test, implying that farmers had developed stronger beliefs that spraying insecticides in the first 40 DAS was unnecessary and a waste of money, affected health and contaminated the environment (Table 12.5). Similarly, in the 12 districts outside the study sites, the farmers' responses to these statements were also significantly changed.

Benefits from not spraying in the early season

In the post-tests, farmers were asked an open-ended question as to the benefits for not spraying insecticides in the first 40 DAS. Savings in costs (insecticide and labour) were cited by 89 per cent of the farmers, followed by reducing health risks (25 per cent), less pollution to the environment (17 per cent) and protection of natural predators (12 per cent). These benefits were displayed in the poster placed in various public places. Most of the farmers (97 per cent) said that they will continue not using insecticides in the first 40 DAS in the next season.

Relationship between belief index and insecticide use

Farmers' insecticide use frequencies were highly correlated with the belief index values in all three surveys, pretest (Pearson 0.109, $p < 0.05$), post-test 1996 (Pearson, 0.414, $p < 0.01$) and post-test 1997 (Pearson. 0.285, $p < 0.01$). These positive relationships imply that individual fanners with high belief indices had a higher tendency to spray insecticides (Table 12.6). Similarly, the correlation in the post-test of the 12 districts in Long An province was also significant (Pearson, 0.36, $p < 0.01$).

Farmer-to-farmer spread and multiplier effects

In the 1996 post-test, about 77 per cent of the farmers who were aware of the media materials ($n = 400$) said that they discussed the message content with members of his or her household, and 67 per cent discussed it with other farmers. Persons with whom the information was discussed included the spouses (57 per cent), the sons and daughters (31 per cent), children (19 per cent), siblings (12 per cent) and other relations (16 per cent). Some farmers recalled communicating the infor-

Table 12.6 *Regression analyses of farmers' insecticide spray frequency and belief index*

	Constant B		*Intercept*			
Monitoring surveys	*Value*	*95% CL*	*Value*	*95% CL*	*F value*	*P*
Pretest 1994	0.075	±0.055	3.020	±0.625	7.376	0.007
Post-test 1996	0.175	±0.036	0.116	±0.313	91.688	< 0.001
Post-test 1997	0.130	±0.034	0.797	±0.283	54.396	< 0.001
In 12 districts	0.142	±0.019	0.434	±0.167	209.804	< 0.001

mation from the media to more than ten persons (33 per cent), whereas most said that they had spoken to five or less persons (44 per cent). The most common situations where the information was discussed were in the field (36 per cent), in the coffee shops (24 per cent) and at dinner parties (24 per cent).

The media approach in the project sites in Long An province stimulated other provincial governments in the Mekong Delta to launch their own programmes using the approach. Between September 1994 and March 1997, 15 provincial governments initiated their own programmes, spending about US$151,000, distributed 340,000 leaflets, 35,000 posters, organized 1390 demonstration plots and broadcast the radio drama about 1550 times. In addition, a total of 356,600 farmers were invited to participate in testing whether early season spraying for leaf folder control was necessary.

In 1996, a post-test survey of 1499 farmers in the 12 districts of Long An province, besides the study sites, was conducted by the Provincial Plant Protection Department to evaluate the spread effect. About 82 per cent of the 1449 farmers interviewed said that they had heard about the heuristic, and 64 per cent said that they had tried it. Of those who tried, 77 per cent said they had stopped spraying in the first 40 DAS. The spray frequency (Figure 12.3) showed that about 20 per cent of the farmers had not applied any insecticides, and most farmers (59 per cent) applied one or two sprays each season (average 1.6). About 37 per cent of the farmers applied their first sprays in the first four weeks, 50 per cent in the second

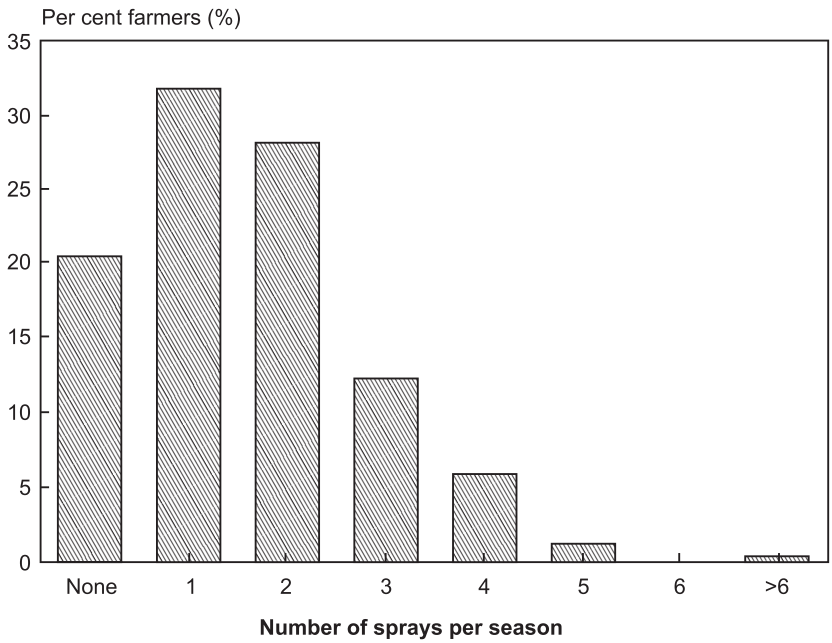

Figure 12.3 *Insecticide spray frequencies of rice farmers in 12 districts in Long An province in September 1996, n = 1449*

four weeks and the remaining 13 per cent after the ninth week. Using farmers' responses to the same five belief statements as in the pretest and the two post-tests, the belief index of farmers in the 12 districts was found to be 8.11 (±0.08 at 95 per cent CL), which was significantly lower than that of the pretest but not significantly different from the 1996 post-test in the study sites. It is evident that the communication media introduced into the two study districts have influenced farmers' pest management beliefs and practices in the whole of Long An.

Farmer field schools

During the study period, a training programme using the FFS approach (Useem et al, 1992; Matteson et al, 1994) was implemented in the province. Table 12.7 shows the number of farmers who were trained by FFS. At the end of 1994, the FFS reached 467 farmers or 2.2 per cent of the households in study sites, whereas the media reached 97 per cent of the population. By the end of 1996, the number of farmers trained in Long An was 7451, accounting for 3.5 per cent of the total farmer households in Long An province. The 1996 post-test survey of 12 districts in Long An province showed that the media reached 82 per cent of the farmer households. The number of farmers trained in the study sites was 1827 or 8.7 per cent. In the 1996 post-test, there were 112 farmers in our sample who had been to the FFS. We regrouped the data and compared the responses of FFS trained farmers and those who had not attended the training. Table 12.8 shows details of the comparison of some of the attributes. FFS trained farmers sprayed less but not significantly lower than untrained farmers, and there were more FFS trained farmers who did not spray any insecticides. The belief index of FFS trained farmers was also lower, although not significantly different, and the proportion of farmers who applied their first insecticide sprays in the first four weeks after sowing was also lower. There was, however, little difference in spray targets as the proportions of sprays for the control of leaf feeding insects was similar. The types of insecticides used also did not differ.

Table 12.9 shows farmers' responses to the belief statements. In all cases, the responses of the FFS-trained farmers and the untrained farmers were not significantly

Table 12.7 *Number of farmers who had attended FFS during the period 1994–1996 in the study sites, Tan Tru and Tan Thanh and in the province of Long An*

	1994	*1995*	*1996*	*Total*
Tan Tru	297	235	262	794
Tan Thanh	170	289	574	1033
Total in study sites	467	524	836	1827
Percentage of household population	2.2	2.5	4.0	8.7
Whole province of Long An	1909	2064	3478	7451
Percentage of household population	0.91	0.98	1.66	3.55

Table 12.8 *A comparison of farmers who were trained through Farmer Field Schools (FFS) and untrained farmers in the 1996 post-test survey in Tan Tru and Tan Thanh districts, Long An province*

Attributes		*FFS trained farmers n = 112*	*Untrained farmers n = 338*
Number of insecticide sprays per farmer	Mean	1.43	1.60
	Mode	1	1
	SD	1.24	1.19
Percentage who did not insecticides	spray	25.9	18.3
Belief index	Mean	7.99	8.29
	95% CL	7.49–8.49	7.98–8.61
Percentage of farmers' sprays targeted at:	rice leaf folders	27.3	39.3
	other leaf feeders	20.3	13.1
	stem borers	28.1	25.4
	brown plant hoppers	6.3	7.9
Percentage of farmers' sprays that were:	methamidophos	27.8	32.9
	methyl parathion	9.3	6.9
	monocrotophos	6.7	10.8
	deltamethrin	7.7	5.9
Percentage of farmer who applied first sprays in first 4 weeks		24.1	38.8

different. For instance, fewer FFS trained farmers believed that insecticides would increase yields (28.6 per cent and 38.0 per cent), leaf folders in the early crop stages could cause yield loss (21.4 per cent and 27.8 per cent), and spraying during the early crop season would be necessary (25.0 per cent and 32.9 per cent). This implied that the FFS training further reinforced farmers' beliefs that leaf folders were not important problems and that spraying was unnecessary.

Insecticide costs and sales in Long An province

The costs of the commonly used insecticides have not changed significantly over the study period (Table 12.10). The sales volume records of five retailers showed that the proportion of insecticide sales declined from 37 per cent of total sales in 1994 to 21 per cent in 1997.

Table 12.9 *Comparison of responses to belief statements by farmer field school (FFS) trained and untrained farmers in Tan Tru and Tan Thanh districts, Long An province*

	Percentage of farmers who agreed to the statements		
	FFS trained farmers	*Untrained farmers*	*Chi-square*
Applying insecticides will increase yields	28.6	38.0	5.33
Insecticides will harm natural enemies	89.2	87.0	0.38
Killing natural enemies can cause more pest problems	40.2	34.6	2.14
Spraying insecticides can harm human health	97.3	96.4	0.69
Spraying insecticides contaminates the environment	63.4	63.5	0.34
Applying insecticides in the first 40 DAS is a waste	85.7	79.9	2.15
Applying insecticides in the first 40 DAS can cause more pests	69.6	71.3	0.49
Leaf folders in the first 40 DAS can cause severe damage	21.4	29.1	2.49
Leaf folders in the first 40 DAS will cause yield loss	21.4	27.8	1.79
Spraying in the first 40 DAS for leaf folder control is necessary	25.0	32.9	2.96
Spraying insecticides for leaf folders has to be done early in the season	17.1	23.1	5.95
Rice crops can recover from early season damage by pests	92.0	85.2	4.77

Note: Critical values of chi-squared at d.f. = 2, $P = 0.05$, 5.99 and $P = 0.01$, 9.21.

Discussion

There are strengths and weaknesses in indigenous farmer knowledge as observed among Honduran farmers (Bentley, 1989), and farmers' beliefs in pests and their perceptions of the potential damage and losses are examples of such weaknesses. Rice farmers in Asia generally overestimate losses due to highly visible pest damage, such as the rice leaf folder (Heong et al, 1994) and stem borers (Lazaro et al, 1993). In Honduras, Bentley (1989) found that farmers were worried about *Diabrotica* beetles, which are large and colourful but not important pests. In insecticide use, farmers' perceived benefits seem to be much higher than the actual benefits. Since perceptions, rather than the economic rational, determine the decisions of farmers, changing these perceptions may reduce the perceived benefits and

Table 12.10 *Prices of some common insecticides used by farmers between 1994 and 1997 in Long An province and mean percentage sales volumes of five retailers*

	Application rates (g ai ha^{-1})	*1994*	*1995*	*1996*	*1997*
Monocrotophos (US$ per 500cc bottle)	500	1.60	1.65	1.90	Banned
Methyl parathion (US$ per 500cc bottle)	500	1.45	1.18	1.36	Banned
Methamidophos (US$ per 480cc bottle)	500	2.20	2.30	2.30	2.30
Deltamethrin (US$ per 100cc bottle)	12.5	1.20	1.28	1.30	1.30
Alpha cypermethrin (US$ per 100cc bottle)	20	0.90	0.85	0.90	1.00
Lambda cyhalothrin (US$ per 250cc bottle)	7.5	3.70	3.80	3.90	4.00
BPMC (US$ per 500cc bottle)	500	1.00	1.14	1.36	1.45
Diazinon granules 10% (US$ per kg)	1000	0.77	0.84	0.93	1.02
Mean percentage of total sales in insecticides		36.6	30.6	24.2	21.4
SD		3.6	3.0	5.2	4.2

intentions to spray. By using the conflict approach, farmers in the Philippines were motivated to stop their early season spraying (Heong and Escalada, 1997a). Using communication materials, farmers in the study sites were similarly motivated and reduced their insecticide sprays by 47 per cent, from 3.35 to 1.76 sprays per season. This reduction seems to be attributed to the change in beliefs as indicated by the reduction in the belief index from 11.3 to 7.6. The direct relationships between number sprays and the belief index further support this conclusion.

Farmers' insecticide spraying in the early crop stages had clearly reduced. Before the introduction of the communication materials, about 60 per cent, 82 per cent and 84 per cent of the farmers applied insecticides during the early and late tillering and booting stages, respectively. Eighteen months after introduction, farmers' spraying during these stages had significantly reduced to 25 per cent, 41 per cent and 55 per cent, respectively. Further reductions to 0 per cent, 19 per cent and 30 per cent were observed 31 months after introduction. As the content of the communication campaign was to motivate farmers to reduce early season spraying, this reduction in early season spraying implied that the campaign had affected farmers' insecticide use. At the heading and maturing stages, there were initial reductions in farmers using insecticides, and spraying was increased although not significantly higher than in the pretest. This increase was also reflected in the increase in mean number of sprays per season, from 1.55 to 1.76. In the 12 districts, the mean number of sprays was 1.58 at about 25 months after launching in Long An. Since these two surveys were done in different crop seasons, the general reduction in the number of insecticides in the whole province of Long An province reflected the effect of the media and not seasonal differences.

Although there appeared to be a substantial perception change in a large proportion of farmers, the rice leaf folders and other leaf feeding insects remained the targets of those farmers who were spraying. These sprays were used later, implying that farmers were still worried about the leaf feeders, particularly leaf folders, that infest crops at the later crop stages.

While the communication materials were introduced, IPM training programmes through the FFS approach were also implemented in the study sites. In September 1994, when the media project started, there were 467 FFS trained farmers in the project sites. When the first post-test was conducted in February 1996, there were 991 FFS trained farmers, and in March 1997, the number increased to 1827. These accounted for 2.2 per cent, 4.7 per cent and 8.7 per cent of the farmer households in the study sites at the time when the surveys were conducted. When we conducted post-tests in 1996 and 1997, most of the FFS trained farmers had been exposed to the media materials. The general reduction in insecticide use and farmers' perception change might be due to one or both of these interventions. In the study sites, the reduction in insecticide sprays, especially in the early crop stages, and the change in perception, were widespread, even among farmers who had not attended FFS. The relatively small proportion of farmers exposed to FFS (< 10 per cent) may not be able to account for these changes over a large proportion of the farmers in the study area. Similar changes were also observed among farmers in other districts of Long An province, where only 3.5 per cent of the farmer households had attended FFS.

We found that FFS trained farmers sprayed less insecticides and had lower belief index scores, although these were not significantly lower than those farmers who had not attended the FFS. In response to the belief statements, more FFS trained farmers had preferred responses than untrained farmers. As farmers in Long An were exposed to the media campaign before attending the FFS, the training further reinforced the perception change initiated by the media.

In the study sites, the media materials were distributed only for one season in 1994, and their effects on farmers' perceptions and practices were sustained for 31 months. Another 15 provincial governments adopted the same approach and extended the campaign to the whole of the Mekong Delta, with an estimated farm household population of about 2 million. It is evident that the new information had diffused to a large population and had reduced the uncertainty of farmers' attitudes toward not using insecticides. The media materials provided information aimed at reducing uncertainty, and this effect was evident from the significant reduction in the belief index. The information was aimed at reducing insecticide use in the early crop stages and a significant reduction in farmers' insecticide spraying during these crop stages was observed.

The adoption rate of an innovation depends on its characteristics (Rogers, 1995). In this case, the innovation has high relative advantages in terms of savings in chemical and labour costs. The innovation is also testable. The campaign emphasized this, and its benefits are also observable. Initially, the innovation was in conflict with farmers' perceptions. However, since it was presented together with an evaluation method and related information, it served as an important incentive to change perceptions (Heong and Escalada, 1997a). Such a change may be further reinforced and sustained by more frequent mass media and training programmes.

Since the approach was easy and inexpensive to adopt, it stimulated 15 provincial governments to establish their own programmes with provincial funds extending the campaign's reach to the entire Mekong Delta. The post-test survey of 12 districts carried out in September 1996 showed that a large proportion (82 per cent) of the farmer households (about 2 million) had been reached, and many had ceased their insecticide spraying for leaf folder control in the early crop stages. In these provinces, the approach appears to be part of the agricultural technicians' routine tasks (or 'routinized'). It is evident that to enhance adoption, the innovation, besides being attractive to its potential adopters, will also need to be attractive to its potential implementers.

Mass media channels are relatively more important at the knowledge stage in the innovation-decision process (Rogers, 1995). They can reach a large audience rapidly, create knowledge and spread information, and these can lead to changes in some weakly held attitudes. Spraying insecticides at the early crop stages, though very common among farmers, may be a weakly held attitude. To change more strongly held attitudes, like insecticide spraying at other times of crop growth for high yields, might require interpersonal channels, like face-to-face exchange means. The information on the leaflets and posters encouraging farmers to contact the Plant Protection Department to learn more about pest management was primarily aimed at facilitating this process.

Discontinuance, a decision to reject an innovation after having previously adopted it (Rogers, 1995), among the adopters is a high possibility. This is especially so because negative messages about the innovation will continue to circulate, through both the mass media and interpersonal networks. Although the results of this study seem to show that insecticide spraying during the early crop stages has been reduced, it is difficult to expect one campaign to sustain the adoption of the innovation. For this cessation of early season spraying to continue, there is a need to provide the same information frequently or similar information framed differently. In addition, there is a need to monitor changes and develop programmes to fully institutionalize and 'routinize' into ongoing practices and value systems of adopters.

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Appendix

Radio drama script used in the broadcasts in Long An province

> Scene: Early one morning in the rice field of Uncle Hai with Uncle Nam, his neighbour passing by carrying a knapsack sprayer
>
> Uncle Nam: Hey Uncle Hai! Why don't we have some coffee instead of visiting your field so early in the morning?
>
> Uncle Hai: Oh, I am watching some friendly insects attacking the worms. How about you? What are you spraying for?
>
> Uncle Nam: My God! My crop is just 10 days old, but there are so many thrips. It looks terrible. So I have to spray it now. Ah, you just mentioned friendly insects. What are they?
>
> Uncle Hai: Take your time. Put down your sprayer and I will tell you what they are.

Uncle (in Vietnamese, Bac) is used as a sign of respect when addressing a senior person in Vietnam.

Uncle Nam: Uh! Uh! I am very worried about my crop. How can I take my time? I will only stay for a short while.

Uncle Hai: Don't worry about thrips. Look at my field. There are lots of thrips there too. Sit down and I will tell you something interesting.

Uncle Nam: Okay. I will sit down.

Uncle Hai: You don't see any flies in my field, do you?

Uncle Nam: There are spiders. Everybody knows that.

Uncle Hai: And what about that insect on the leaf?

Uncle Nam: Quit joking with me. Even children know that it is a dragonfly.

Uncle Hai: Ay! It's that easy. I've just answered your questions. Those are the friendly insects. And now do you know why they are called friendly insects?

Uncle Nam: No. Why?

Uncle Hai: Because they live in the rice fields. Sometimes farmers think they are harmful but they really don't feed on the rice plants. Instead, they are looking for brown plant hoppers, leaf folders, stem borers, army worms and case worms to eat. They are farmers' friends because they eat these bad insects. So you don't have to spray to get a good crop.

Uncle Nam: A good crop without spraying? You are joking with me again. What does your crop look like without insecticides?

Uncle Hai: Ay! Ay! Do you remember my last crop? I got more than 30 gia per cong. You can ask my neighbours to confirm that I did not spray any insecticides.

Uncle Nam: Uhhhhh. It sounds ridiculous. I would like to know why.

Uncle Hai: Okay. Do you remember the situation in my field last season? The rice leaf folder damages looked very serious, but I did not spray. And I still got a good crop. Now look at my field. There are thrips and leaf folders as well, but I shall still not spray.

Uncle Nam: Really??

Uncle Hai: Sure!! During the first 40 days after sowing, rice plants can recover from leaf removal by leaf folders. If you spray, you will waste money and sometimes you will suffer from brown plant hopper damages.

Uncle Nam: What a surprise!! It is hard to imagine.

Uncle Hai: It takes some time to explain the details. You have to buy me a drink.

Mr Ha, the local agricultural technician joins the two farmers.

Mr Ha: Hey!! What are you talking about? I just heard 'buying a drink'. Is there something interesting??

Uncle Hai: Uh! Uh! By the way, Mr Ha, can you tell us about testing whether early season insecticide spraying is needed in the field? You advised me about the experiment last season.

Uncle Nam: Well. Mr Ha, please tell me about it, and I can also try it in my field.

Uncle Hai: Oh, it is very easy.

Mr Ha: Yes. It takes some time to describe this, but the experiment is easy to perform. Now how many cong of field do you have? How old is your crop? Are you going to spray right now?

Uncle Nam: I have 5 cong. My crop is 10 days old. I am going to spray this morning for thrips and leaf folders.

Mr Ha: Well. It is good that you have not sprayed yet. If you want to try, you can divide your field into two parts. Do not spray one part of 2 or 3 cong. Spray the rest as normal. At harvest, we can compare the yields of these parts. You may find that there is no difference in yields.

Uncle Nam: Two or 3 cong? That is too big. What if something goes wrong?

Mr Ha: I assure you that there will be no yield difference. If you are still worried, use one cong as the unsprayed plot. I am afraid you might be sorry for unnecessarily spending money in insecticides and spraying.

Uncle Nam: Are you sure? Okay, I will follow your advice and try the experiment.

Uncle Hai: Come on Uncle Nam! I am sure. I have grown two crops without spraying in the first 40 days and have no yield loss. I save money and work and also have no hopper problems.

Uncle Nam: Well, I will try.

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13

Landcare and Livelihoods: The Promotion and Adoption of Conservation Farming Systems in the Philippine Uplands

R. A. Cramb and Z. Culasero

Introduction

Agricultural land degradation in the densely populated, steeply sloping upland regions of the Philippines has been recognized as a major environmental problem in the past three decades, with significant on-site and off-site impacts (Cramb, 1998). Conservation farming systems have been developed, such as the widely promoted Sloping Agricultural Land Technology (SALT), based on contour hedgerows of shrub legumes, but sustained uptake by farmers has been limited (Cramb, 2000; Cramb et al, 1999, 2000). In recent years, interest has focused on the potential of the landcare approach to enhance the development, dissemination and adoption of appropriate conservation farming measures (Mercado et al, 2001).

Landcare emerged in the mid-1980s in Australia and in the late-1990s in the Philippines as an important strategy for developing collective action at the local level to deal with problems of agricultural land degradation. The landcare approach centres on the formation of community landcare groups, supported to varying degrees through partnerships with government and non-government agencies. Campbell defines a community landcare group as 'a group of people concerned about land degradation problems, who are interested in working together to do something positive for the long-term health of the land' (1994, p31). Such groups identify problems at the local level and mobilize information, community effort and finances to help improve the management of their soil, water, vegetation and other natural resources. It is widely held that this is a more effective strategy for

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Figure 13.1 *Location of principal landcare sites in Mindanao, Southern Philippines*

achieving adoption of sustainable farming practices than strategies involving government regulation or the top-down transfer of technology.

This paper reports some of the results of a participatory evaluation of the Landcare Programme in Mindanao in the Southern Philippines (Figure 13.1). The evaluation study was undertaken in the final phase of a four-year action research project (1999–2003) funded by the Australian Centre for International Agricultural Research (ACIAR). The focus of this paper is Barangay Ned, part of Lake Sebu Municipality in the province of South Cotabato in Southern Mindanao. The Landcare Programme in Barangay Ned is of particular interest because it has been faced with extremely difficult conditions, has received minimal outside support, and thus indicates perhaps the basic requirements for achieving an accelerated impact on upland farming systems in the Philippines. The sustainable rural livelihoods approach was used in this study as a framework to understand, explain and evaluate the impacts of the Ned Landcare Programme.

Background

The Landcare Programme in the Philippines

Independently of the Australian Landcare Programme, landcare in the Philippines grew out of efforts to promote soil conservation innovations among farmers in the upland municipality of Claveria in Northern Mindanao (Arcenas, 2002; Sabio, 2002). The Department of Agriculture (DA) began promoting contour hedgerows of shrub legumes in the early 1980s, in the form of the SALT package. In 1987, the International Rice Research Institute (IRRI) in collaboration with the DA initiated a farmer-to-farmer training programme in Claveria to enhance adoption. By 1992 up to 80 farmers had adopted the technology.

The International Centre for Research in Agroforestry (ICRAF) took over the IRRI research site in Claveria in 1993 and proceeded to conduct field trials on contour hedgerow systems. In 1996 ICRAF identified a low-cost farmer adaptation of contour hedgerows – the use of natural vegetative strips (NVS) as an alternative to the more complex and labour-intensive method of establishing and maintaining hedgerows of shrub legumes or forage grasses (Arcenas, 2002; Mercado et al, 2001; Sabio, 2002; Stark, 2000). A three-person extension team, comprising a farmer who had adopted NVS, a DA extension agent and an ICRAF technician, was formed to promote the NVS technology. The team worked initially with individual farmers in various villages (*barangay*), but the interest was such that group sessions were organized, involving 20–25 participants. At one of these group-training sessions in 1996, 20 farmer leaders, at the suggestion of one of the facilitators, decided to form a farmer organization to promote the NVS contour hedgerow system within the Claveria community. The organization was named the Claveria Land Care Association (CLCA).

The Landcare Programme in Claveria developed into a triangular partnership between the CLCA (a people's organization, working collectively to encourage conservation farming among its members), ICRAF (an international non-government organization, providing technical and logistic support and facilitation) and local government units (providing public resources and official support for the Association). As a result of this partnership, by early 2000 the CLCA had grown to include 16 chapters, 105 sub-chapters, and about 800 individual farmer members. Adoption of NVS technology also increased dramatically, from about 75ha in 1996 to more than 300ha in 1999. Arcenas (2002) reports that all partners credited the farmer-based group extension approach of the CLCA as the principal factor in this increased level of interest and adoption.

The success of Landcare in Claveria encouraged ICRAF in 1998 to introduce the approach at its Central Mindanao field site in the Municipality of Lantapan in Bukidnon (Figure 13.1), and to seek external funding both to support the programme and to evaluate its potential as a model for community-based natural resource management throughout the Philippine uplands. Operational funding was obtained from the Spanish Agency for International Cooperation (AECI). As mentioned above, the ACIAR funded an action research project from 1999 to 2003 to augment and help evaluate the ongoing Landcare Programme in these and other sites.

The ACIAR Landcare Project

The ACIAR Landcare Project helped support the Landcare Programme in and around the Claveria and Lantapan sites, as well as a third site in Southern Mindanao – Barangay Ned (Figure 13.1). Previous projects implemented in Barangay Ned by the Southeast Asian Regional Centre for Graduate Study and Research in Agriculture (SEARCA) had sought to develop and promote conservation farming technologies, partly through the formation of farmer work groups. Hence this site was readily included in the Landcare Programme, with SEARCA as the facilitating organization, providing a further opportunity to test the replicability of the landcare approach as it had evolved in Claveria.

The principal aim of the ACIAR Landcare Project was to test the effectiveness of the landcare approach as a tool to enhance the adoption of conservation practices suited to the needs of upland farming communities in the Philippines. As in Australia (Campbell, 1994; Cary and Webb, 2000; Lockie and Vanclay, 1997), 'the landcare approach' in the Philippines means many things, making evaluation difficult. In the ACIAR project, the impact of landcare was to be evaluated in terms of: (1) the adoption of conservation practices (and the effect of these practices on natural resources); and (2) the relevance of the approach as a model for local and regional extension services. That is, the project was interested in the adoption of both landcare *technologies* and landcare *processes and institutions* (notably the formation and development of landcare groups and networks). These impacts were seen to be critical to the achievement of the longer-term outcomes of rural poverty reduction and environmental conservation – in short, sustainable rural livelihoods.

Methods

The sustainable rural livelihoods framework

A major methodological advance in rural development research in recent years has been the recognition that rural households are not necessarily focused exclusively on increasing crop or livestock production and incomes (let alone on resource conservation), but undertake a range of activities, both on- and off-farm, depending on the resources to which they have access and the livelihood strategies they are able to pursue at any given time (Chambers, 1987; Chambers and Conway, 1992). This 'sustainable rural livelihoods' approach is now widely advocated as a framework for evaluating and developing policies and programmes at the micro level, particularly in terms of poverty reduction (Ellis, 2000; Scoones, 1998). While not inconsistent with a farming systems approach, it goes beyond the focus on agricultural production technology typical of much farming systems research (Ellis and Biggs, 2001).

A livelihood is a means of earning a living. Within the livelihoods approach, 'a livelihood comprises the assets (natural, physical, human, financial, and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household' (Ellis, 2000, p10). This emphasis on assets, activities and access provides a convenient framework within which to develop an understanding of the complex and dynamic realities of rural households. Ellis (2000) places less emphasis on the sustainability dimension because of what he sees as its inherent vagueness, but Scoones considers that 'a livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base' (1998, p5).

Scoones outlines the essential components of livelihoods analysis as follows:

> The key question to be asked in the analysis of sustainable livelihoods is – Given a particular *context* (of policy setting, politics, history, agroecology and socio-economic conditions), what combination of *livelihood resources* (different types of 'capital') result in the ability to follow what combination of *livelihood strategies* (agricultural intensification [or] extensification, livelihood diversification, migration) with what *outcomes*? (Scoones, 1998, p3)

Ellis (2000) gives particular emphasis to the widespread strategy of rural livelihood diversification, which he defines as 'the process by which rural households construct an increasingly diverse portfolio of activities and assets in order to survive and to improve their standard of living' (Ellis, 2000, p15). Diversification includes on-farm diversification (as measured by the range of crop, livestock and other natural resource-based activities undertaken) as well as diversification away from own-account farming to include off-farm and non-farm activities in the household's portfolio. The potential outcomes of these and other livelihood strategies are grouped by Ellis (2000) into: (1) livelihood security (income level, income stability, seasonality, risk); and (2) environmental sustainability (soil and land quality, water, forests, biodiversity).

The livelihoods framework has the advantage of placing the adoption of landcare practices and the formation of landcare groups within the context of the livelihood resources and strategies of farm households and local communities, thus explicitly linking farming systems change, rural development and natural resource management. In particular, the landcare approach can be seen as promoting sustainable rural livelihoods primarily through investment in human and social capital. While the notion of human capital is well established, social capital is a relatively new concept, hence it warrants a brief discussion here. Woolcock (1998) and

Woolcock and Narayan (2000, p226) define social capital succinctly as 'the norms and networks that enable people to act collectively'. They make the useful distinction between 'integration' or 'bonding social capital', i.e. the intra-community ties that enable poor people in a village setting to 'get by' (e.g. monitoring of property rights, labour exchange, emergency assistance, rotating savings groups, provision of communal facilities) and 'linkage' or 'bridging social capital', i.e. the extra-community networks that enable individuals and groups to tap outside sources of information, support and resources, not just enabling them to 'get by' but to 'get ahead' (e.g. links to traders and financiers, extension agents, NGOs). For development to proceed, Woolcock and Narayan (2000) suggest there is a need, not only to mobilize bonding social capital, but also to develop new linkages, or bridging social capital, opening up new opportunities for individuals and communities. The dilemma is that the formation of this latter type of social capital may well undermine the former type over time, because group success both increases demands on existing social bonds and encourages individuals within the community to pursue a greater diversity of linkages and activities. Pretty (2003) and Pretty and Ward (2001) have documented the growth of social capital as evidenced by group activity in a wide range of natural resource management sectors, including watershed management, irrigation, micro-finance, forest management, integrated pest management and farmer experimentation. The relationship between social capital and soil conservation is examined by Cramb (2004).

Sources of data

The study in Barangay Ned was based on four main sources of data: (1) project reports and statistics; (2) interviews with project staff and other key informants; (3) two questionnaire surveys; and (4) nine case studies of community landcare groups (Cramb and Culasero, 2003).

The first survey was conducted in mid-2001. The questionnaire was administered by local, trained enumerators to a stratified random sample of 313 farmers from 18 *sitio* (sub-villages), representing approximately 11 per cent of the total number of farm-households in Ned. A follow-up survey was conducted in the third quarter of 2002, using the same sample as for the 2001 survey, although only 310 of the original 313 respondents could be contacted. As well as repeating questions about the extent of adoption, the second questionnaire included questions about landcare membership and farmers' perceptions of changes in key aspects of their farming operations since the adoption of conservation measures.

Case studies of nine community landcare groups were undertaken. The groups were selected based on their relative accessibility and their reported level of activity. The case studies were based on focus group discussions and key informant interviews, conducted from August to October 2002. There were 21 participants in focus group discussions and 60 key informants, including 51 landcare members, 8 local government officials and the Landcare Facilitator for Ned. A flexible schedule of open-ended questions was used to probe the informants about their perceptions of Landcare, the history of their group, the factors promoting and inhibiting participation in the group, the development and current status of group activities, the benefits or impacts of these activities and the prospects for the future.

For the sake of brevity, only the first three sources of data are drawn upon directly in the following section. Nevertheless, the results of the case studies were broadly consistent with the findings from the project interviews and the household surveys, and help to inform the overall discussion below. A full report of the evaluation study can be found in Cramb and Culasero (2003).

Results

The context of rural livelihoods in Barangay Ned

Barangay Ned, though part of Lake Sebu Muncipality, is an atypical *barangay*, given its size and relative isolation from the municipal centre, and is on the way to becoming a municipality in its own right. It encompasses an area of over 41,000ha, comprising the Ned Settlement Area (22,000ha) and the Tasaday Reservation (19,000ha) (a forest reserve created in 1972, ostensibly to protect a small 'stone-age' tribe). In 2000 it had a total population of nearly 15,000, grouped into 30 *sitio*. The population density in the settlement area averaged around 65 persons per square km, but was higher in the northern half of the area, which had primitive road access.

Barangay Ned was established in 1962, but poor accessibility and lack of security hindered development until the early 1980s. It was originally part of the T'boli homelands but various logging concessions were granted from the 1960s and, from the 1980s, Ilonggo and other settlers moved in an acquired logged-over and other land, leaving the T'boli in the minority. In the 1990s the Department of Agrarian Reform (DAR) allocated titles to 5575 beneficiaries occupying 16,700ha, or 75 per cent of the settlement area. DAR also took responsibility for coordinating rural development in Ned, and contracted SEARCA in 1992 to implement the Ned Agro-Industrial Development Project (NAIDP), which included a component promoting conservation farming. However, support for T'boli swidden farmers was limited, leaving many of them feeling alienated from the agrarian reform process.

The climate in Ned is characterized by abundant rainfall (averaging 2200mm) uniformly distributed throughout the year, high levels of humidity and cloudiness, and moderate temperatures (averaging 21°C) due to an average elevation of 900m. Hence continuous cultivation is feasible and a wide range of crops suited to tropical and subtropical environments can be grown. The terrain is rolling to mountainous, with dominant slopes of 12–40 per cent The soils are predominantly neutral to acidic sandy-loams with a clay B horizon, of low to moderate fertility, and highly susceptible to erosion. Permanent cropland accounts for about 14,000ha

(64 per cent of the settlement area), including maize (8000ha), upland rice (2000ha), and other crops (4000ha). Grassland accounts for about 2750ha (12 per cent), and forest land (mainly degraded forest with small pockets of primary forest) for perhaps 4500ha (20 per cent).

Sitio Kibang, site of the DAR office in the northern part of Barangay Ned, is located roughly 110km from Koronadal, the capital of South Cotabato, and just over 60km from Isulan in Sultan Kudarat, the nearest major market centre (Figure 13.1). Access is via a former logging road, which becomes impassable after heavy rain. Large trucks, jeepneys and motorcycles ply this route, but transportation is limited to motorcycles when road conditions deteriorate. Maize, the main commodity produced, is sold to the few private traders in Kibang or directly to Isulan, where prices are 30–40 per cent higher. Likewise, fertilizer, the main farm input used, is purchased from local traders or in Isulan, with a similar price differential. The margins largely reflect the high transport costs. There are six functioning cooperatives in the northern *sitio*, three of which deal with farm produce as well as consumables. Traders provide short-term seasonal credit for farm inputs, at interest rates of 5–25 per cent per month, as well as for consumption needs. Larger and longer-term capital requirements are often financed by mortgaging land.

Employment is largely confined to agriculture, whether on- or off-farm; there is little non-farm employment in the *barangay*. Farm size averages just over 3ha. While most farmers have titles to their land (Certificates of Land Ownership Award or CLOA) issued by DAR in the 1990s, the tenure situation is complex and dynamic. Despite a ten-year restriction on the sale of CLOA, informal transactions have taken place and are accepted in the community. Some landowners have rented part or all of their land to tenants under a share-cropping arrangement. In other cases the land is mortgaged, with the mortgagee, the mortgagor or a tenant farming the land. Hence a significant proportion of farmers are not owner-operators.

Though shifting cultivation of rice was once dominant, by the 1990s the farming systems of both indigenous and migrant farmers involved continuous cultivation of maize and (to a lesser degree) upland rice. Use of hybrid maize seed and inorganic fertilizer was increasing. The typical cropping pattern involves two croppings per year, with upland rice or maize cultivated in the first cropping and maize in the second. Maize is mainly cultivated for sale, while upland rice is mainly for home consumption, though maize is also consumed as a staple.

Neither maize nor upland rice cultivation involved the use of soil conservation measures until NAIDP's introduction of contour hedgerows or SALT in the mid-1990s, which over 100 farmers had at least partially adopted. An on-farm research project within NAIDP (funded by ACIAR) also contributed to awareness of improved practices for steeplands. This project worked with farmer-cooperators to test a range of potentially high-value field crops (e.g. garlic, ginger and crucifers) and tree crops (e.g. coffee, mangosteen, durian and rambutan), integrated into three conservation farming options. The Mindanao Baptist Rural Life Centre (MBRLC) established a presence in some of the more remote *sitio* and also promoted adoption of SALT.

The difficult marketing environment had limited agricultural diversification. Taro, peanuts and beans were cultivated to a limited extent. Bananas were grown extensively, but only for the local market. Limited development of bunded rice fields had occurred along stream margins. Tree crops such as coffee, cocoa and fruit trees had been planted on a limited scale. Many households raised *carabao*, horses and chickens, while pigs and goats were raised by a smaller number of households.

Barangay Ned thus provided a formidable challenge for the Landcare Programme. On the one hand, the site imposed severe limitations. The rural landscape had undergone rapid transformation due to the combined effects of shifting cultivation, logging and land clearance, exposing the soil to severe degradation. Increasing population density and isolation from markets dictated a farming system based on continuous cultivation of cereals, especially maize, which served as the only cash crop and increasingly as a substitute staple for rice. Farmers were poor, with little education, mostly lacking in experience of this upland environment, and not highly organized, relying on face-to-face contacts in small clan groupings and local neighbourhoods for support. Though aware of soil erosion, they lacked the knowledge and means to combat it. On the other hand, the site's considerable agricultural potential, the dynamism characteristic of a frontier settler society, and the relative lack of previous intervention by agencies providing agricultural research and extension, meant the Landcare Programme could expect to generate a positive response among farmers.

The Ned Landcare Programme

The Landcare Programme was well placed to build on the conservation farming component of the NAIDP and the on-farm research of the earlier ACIAR project. As the implementing agency for both projects, SEARCA could provide institutional continuity for the Landcare Programme, including first-hand awareness of the successes and failures of the previous efforts. Most important, the Landcare Facilitator had five years experience working for the ACIAR on-farm research project, developing and testing new farming practices with farmers and researchers. Thus the legacy of the two previous projects was that: (1) the Facilitator had considerable locally validated technical expertise, as well as credibility in the farming community; (2) there was already a pool of farmers around Kibang who had adopted contour hedgerows, experimented with alternative annual and perennial crops, and learned the benefits of working and learning together in small groups; and (3) there was experience in working with part-time, paid farmer-trainers.

As part of the larger ACIAR Landcare Project, the Ned Landcare Programme brought two new emphases – the promotion of NVS as a simpler, lower-cost alternative to legume hedgerows and the formation of community landcare groups (as well as a Landcare Association and Landcare Advisory Group). Apart from the emphasis on groups, the Landcare Programme was primarily a programme of extension and training in technical aspects of farm development, including conservation measures and the establishment of new crops. Initially the Programme emphasized the 'high-value' field crops that the earlier ACIAR project had tested, but as problems of pest management and marketing emerged, and as previously planted fruit trees began to bear, the emphasis shifted to perennials – first coffee, then increasingly durian and other fruit trees. Farmers' interest in acquiring planting materials and technical knowledge for crop diversification was used as the 'entry point' to encourage both adoption of conservation measures and membership of landcare groups. This strategy was highly successful – many landcare groups were formed and most landcare members established contour barriers on their farms.

There was rapid formation of landcare groups over the first three years of the Landcare Programme, but at a declining rate (Figure 13.2). By 2002 there were 39 groups with 366 members, roughly 10 per cent of farm households in Ned. Whereas the Landcare Facilitator had initiated most of the groups formed in the first 12–18 months of the project, the appointment of part-time farmer-facilitators in mid-2000 meant that they took most responsibility for forming and supporting groups from that time, working as intermediaries between the Landcare Facilitator and the groups. Farmers also formed groups on their own, and in some cases helped neighbouring groups to get established. The growth in total landcare membership followed a similar path to the total number of groups, meaning there was no overall growth in the size of groups. Larger *sitio*-level groups tended to break up into smaller *purok*-level groups (a *purok* is a hamlet), reducing the costs to members of participation in meetings and group work, though some of these groups lacked leadership and lost momentum. Security problems in the south of the *barangay* disrupted some groups.

There was a steady rate of adoption of contour barriers by landcare group members – about 50ha a year. In most cases group activities (such as meetings and group work) declined once most members had been helped to implement contour

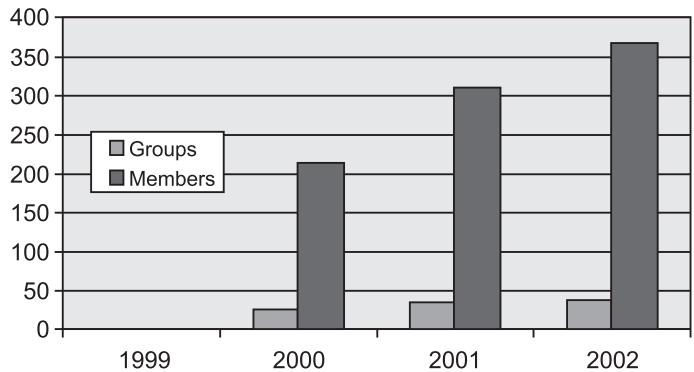

Figure 13.2 *Number of landcare groups and members in Ned*

barriers. The ongoing interest in fruit tree production was largely met through establishment of individual rather than group nurseries, though landcare membership provided access to group training events and assistance from facilitators. However, a few groups had developed sufficient momentum to move beyond the initial focus on conservation farming, developing their own projects to meet the needs of members, e.g. for cheaper farm inputs and medicines.

The training provided to landcare groups appeared to decline over time, which may have been one reason for the general decline in group activity. The training was mainly technical, dealing with contour farming, vegetable production, and propagation and establishment of perennials, though there was an increase in the number of training events dealing with group organization and facilitation.

The Ned Landcare Association (NLCA), formed in 1999, comprised the leader of each landcare group as well as the Landcare Facilitator and staff of DAR and MBRLC. It was an active association, no doubt helped by the involvement of the Facilitator. It met quarterly to exchange information, planned and organized *barangay*-wide landcare activities and took initiatives on behalf of the landcare groups, securing grants and loans for nursery materials and seeds. A Landcare Advisory Group was established but probably added little to the informal linkages developed by the Landcare Facilitator.

Linkages with local government units (LGU) were relatively weak. Officers of the Barangay Council gave little attention to Landcare, though more recently there were moves by landcare leaders to get representation on the council, and the Landcare Association had secured a grant from the council. As Barangay Ned was remote from the municipal LGU, the mayor and other officials knew little about the Landcare Programme. Other institutions provided minimal support, though the MBRLC collaborated closely with the Landcare Programme.

Impacts of the programme

Based on the household survey, over a third of farmers in Barangay Ned (38 per cent) had adopted conservation measures (vegetative barriers, physical barriers and/or tree planting), affecting about 16 per cent of the total cultivated area (Table 13.1). As conservation measures were adopted preferentially on steeply sloping land, the impact of adoption on the catchment as a whole would have been greater than the figure of 16 per cent suggests. In most cases the adopted measures were considered effective in controlling erosion and had been maintained or expanded. Further expansion of vegetative or physical barriers on adopters' farms was slow, but expansion of tree planting, especially fruit trees, was underway. There was evidence that diffusion of conservation practices to additional farmers was still occurring.

The primary reasons for adopting (or planning to adopt) conservation measures were to control erosion and restore soil fertility. Prospective adopters were also hoping to receive benefits from the Landcare Programme, especially fruit tree seedlings. The main reasons given for not yet adopting were the lack of time or interest, the perceived difficulty of maintaining contour hedgerows and lack of ownership rights to the land.

A statistical comparison between adopters and non-adopters suggested that age, education, gender, place of origin, farming experience in the region, availability of family labour for farm work, engagement in off-farm employment and accessibility to the market centre and to extension personnel were not in themselves major factors in the adoption decision (Table 13.2). Non-adopters seemed as *aware of soil erosion* as adopters. Farmers with larger farms who owned part or all of their farms were significantly more likely to be adopters (Table 13.2), though the relationship between farm size, tenure and adoption was complex and dynamic. The main difference between adopters and non-adopters was that more of the former had acquired *knowledge of conservation measures*, mostly within the previous eight years (Table 13.3; Figure 13.3). This had occurred primarily through practical, farmer-led training events arranged by SEARCA and other agencies (both before and during the Landcare Programme), and secondarily through observation of neighbour's farms where conservation measures had been implemented (Table 13.4).

Farmers' perceptions of trends within their farming operations gave some insight into the impact of adopting conservation measures. Adoption was associated with relatively favourable net trends in maize yield (though not farming operations gave some insight into the necessarily in total maize output), soil loss, soil impact of adopting conservation measures, fertility, use of fertilizer, forage supply and the planting of fruit trees. However, adoption was also associated with an increased workload for men and did not yet result in a clear trend in farm cash income.

The Landcare Programme was widely known and about 25 per cent of the farmers surveyed were members of a landcare group. Landcare membership was positively associated with adoption (51 per cent of adopters were landcare members compared with only 8 per cent of non-adopters; Table 13.5). However, membership in itself was neither necessary nor sufficient to induce adoption of

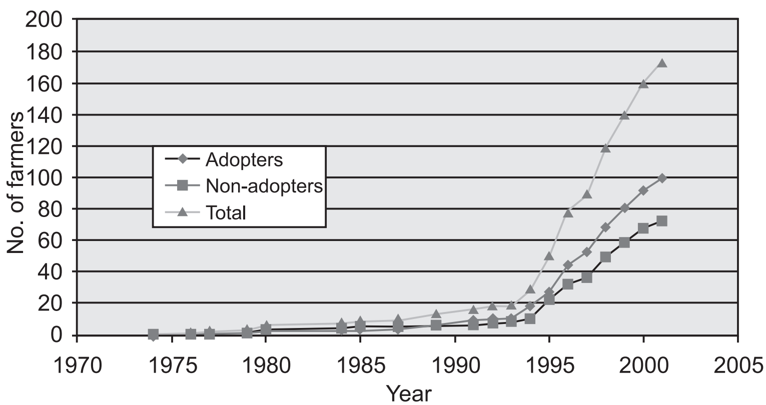

Figure 13.3 *Growth in knowledge of soil conservation measures among survey farmers in Barangay Ned to 2001*

Table 13.1 *Extent of adoption of conservation measures in Barangay Ned, 2002*

Conservation measure(s) adopted	*Vegetative barriers (VB)*	*Physical barriers (PB)*	*VB and/or PB*	*Tree planting (TP)*	*VB, PB and/or TP*
No. of adopters	84	29	99	32	119
% Total farmers in sample	27.1	9.4	31.9	10.3	38.4
Average farm size of adopters (ha)	3.8	3.8	3.8	3.6	3.8
Area of adopted measure – mean (ha)	1.3	1.0	1.4	0.8	1.4
Area of adopted measure – range (ha)	0.25–5.0	0.1–3.0	0.25–5.0	0.25–3.0	0.25–8.0
Area of adopted measure as % of adopters' farms	34.8	26.7	36.6	22.9	36.8
Area of adopted measure as % of total farm area in sample	10.5	2.8	13.3	2.5	15.8

Table 13.2 *Characteristics of farm households in Barangay Ned, by adoption category, 2001*

Characteristic	*Adopters (n = 106)*	*Non-adopters (n = 207)*	*Total (n = 313)*
Mean age of household head (years)	42.5	38.9	40.1
Mean education of household head (years)	6.9	6.0	6.3
Mean residence of household head (years)	13.9	12.5	13.0
Indigenous to area (T'boli) (%)	15.1	18.8	17.6
Female-headed households (%)	1.9	1.9	1.9
Occupation of household head			
on-farm work only (%)	77.4	75.4	76.0
off-farm work only (%)	0.0	1.0	0.6
both on-and off-farm work (%)	22.6	22.2	22.4
Mean no. of household members	5.5	5.2	5.3
Mean no. of farm workers	2.6	2.5	2.6
Mean area of farm (ha)*	3.5	3.0	3.2
Tenure status*			
owner-operator (%)	61.3	48.3	52.7
non-owner (%)	16.0	34.8	28.4
mixed tenure (%)	22.6	16.9	18.9

Note: * Indicates means or proportions for adopters and non-adopters were significantly different at the 5 per cent level.

Table 13.3 *Knowledge of conservation measures reported by farmers in Barangay Ned, by adoption category, 2001*

Conservation measures	*Adopters (n = 106)*		*Non-adopters (n = 207)*		*Total (n = 313)*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Hedgerows*	71	67.0	49	23.7	120	38.3
Natural vegetative strips*	30	28.3	15	7.3	45	14.4
Contour ploughing*	11	10.4	9	4.4	20	6.4
Bench terraces*	9	8.5	1	0.5	10	3.2
Contour bunds*	12	11.3	3	1.5	15	4.8
Contour fencing	4	3.8	2	1.0	6	1.9
Contour composting	3	2.8	2	1.0	5	1.6
Drainage canals	2	1.9	2	1.0	4	1.3
Soil traps	3	2.8	0	0.0	3	1.0
Minimum tillage	2	1.9	0	0.0	2	0.6
Rockwalls	1	0.9	0	0.0	1	0.3
Contour canals	0	0.0	0	0.0	0	0.0
Other field measures	3	2.8	0	0.0	3	1.0
Planting trees*	33	31.1	18	8.7	51	16.3
Any measure*	105	99.1	75	36.2	180	57.5

Note: * Indicates proportions for adopters and non-adopters were significantly different at the 5 per cent level.

Table 13.4 *Source of knowledge about conservation measures reported by farmers in Barangay Ned, by adoption category, 2001*

Source of knowledge about conservation measures	*Adopters (n = 106)*		*Non-adopters (n = 207)*		*Total (n = 313)*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Seminar/training	56	52.8	30	14.5	86	27.5
Observation of other farms	43	40.6	36	17.4	79	25.2
Parents	10	9.4	10	4.8	20	6.4
Farm leader	8	7.6	5	2.4	13	4.2
Organized cross-farm visit	10	9.4	1	0.5	11	3.5
Another farmer's advice	2	1.9	5	2.4	7	2.2
Demonstration plot	2	1.9	2	1.0	4	1.3
Other	9	8.5	5	2.4	14	4.5

Table 13.5 *Landcare membership status, by adoption category, 2002*

Landcare membership status	*Adopters*		*Non-adopters*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Current member*	61	51.3	16	8.4	77	24.8
Former member	15	12.6	20	10.5	35	11.3
Current or former member*	76	63.9	36	18.9	112	36.1
Never a member	38	31.9	107	56.0	145	46.8
No answer	5	4.2	48	25.1	53	17.1
Total	119	100.0	191	100.0	310	100.0

Note: * Indicates proportions for adopters and non-adopters were significantly different at the 5 per cent level.

conservation practices – almost half the adopters were not landcare members and over 20 per cent of landcare members were not adopters. This suggests that extension and training, and observation of neighbouring farms, were more influential in encouraging farmers to adopt conservation measures than landcare membership per se. Landcare members were more likely to have participated in formal training and cross-farm visits, however, in some cases this would have preceded rather than followed the formation or joining of a landcare group.

The main reasons given for joining a landcare group were economic – to learn about farm technologies and receive benefits such as tree seedlings. Secondary reasons were social in nature – to have a group of friends and attend meetings. Where problems were encountered they centred on misunderstandings, poor communication, lack of participation and disunity within the group, all related to lack of leadership or regular contact with a facilitator. In some cases this had led to members dropping out or the group disbanding. Non-members generally felt they were too busy to join or that there was no point as they were not landowners.

Discussion

In this section, the facts of the Landcare Programme in Ned as summarized above are analysed and interpreted explicitly from a sustainable livelihoods perspective. At the outset the farming community in Ned was severely lacking in access to livelihood resources, including physical, financial, human and social capital (especially bridging social capital), and as a consequence was rapidly depleting its natural capital. The dominant livelihood strategies from the early 1980s had been, first, migration into the Ned Settlement Area, followed by 'extensification' through land clearing, then intensification of the farming system, with very little opportunity for on- or off-farm diversification. For indigenous farmers, the opening up of their lands to logging and settlement had also necessitated a strategy of agricultural intensification. The main institution mediating access to resources had been DAR, allocating equal-sized lots to agrarian reform beneficiaries. However, informal land and capital markets developed, leading to a rapidly growing inequality in access to land. The result was differential livelihood outcomes for different classes of farm household, especially owners and tenants. Though outcomes varied, for many households livelihood security was not assured and environmental sustainability was also under threat. Hence there was a ready interest in the Landcare Programme's twin emphasis on soil conservation and developing new livelihood activities.

Building on previous project experience in Ned, the Landcare Programme became an important new element in the farmers' institutional environment, particularly in the form of the resident Landcare Facilitator, whose commitment, skills and local reputation were crucial to the Programme's success. As described above, the Programme targeted: (1) the training of farmers in soil conservation (especially NVS) and agroforestry, with a high degree of involvement of farmer-adopters in the training process; and (2) the formation of landcare groups, linked in a landcare association. In other words, the Programme focused on building human capital (in the form of knowledge and skills to implement soil conservation measures and other farm improvements) and social capital (in the form of improved communication and cooperation through local landcare groups, linked in a barangay-wide landcare association). The Programme provided little in the form of financial capital, though planting materials were an important input. In evaluating the Programme it is important to assess the relative importance of these different forms of capital investment and their interrelationships.

The evidence suggests that the enhancement of human capital was the key to the rapid adoption of soil conservation measures. While adoption was positively associated with farm size and ownership, the main distinguishing feature of adopters was their exposure to training. The practical, farmer-to-farmer nature of this training was the key to its effectiveness, combined with the relative simplicity and effectiveness of the contour farming technology promoted. While soil conservation was a primary focus of landcare training activities, farmers were at least as interested in accessing new livelihood opportunities, principally through planting fruit and timber species in their contoured farms. Linking adoption of conservation measures to these new opportunities was an effective strategy.

On the face of it, the building of social capital was of secondary importance. Though formation of landcare groups assisted members to learn about and implement conservation practices, many adopters were not landcare members and not all landcare members were adopters. Those farmers who joined landcare groups did so primarily to access training, technical advice and assistance (e.g. with planting materials), that is, to augment their human and, to some degree, their financial capital. While a few landcare groups developed a dynamism of their own, identifying new needs and organizing activities to meet those needs, most groups became less active once members had been assisted to contour their farms. Some groups disbanded because of internal conflicts or external changes. The personal qualities of the group leader were a key factor in maintaining and expanding the group's activities, along with the degree of contact and support from landcare facilitators (including farmer-facilitators).

Nevertheless, some members of apparently defunct groups suggested that because group members were close neighbours or kin, they could readily reactivate the group if there was a perceived need, suggesting that their social capital had not been eroded and, in fact, existed independently of the formation or demise of their landcare group. Moreover, the Landcare Association, working on behalf of the local groups and in conjunction with the Landcare Facilitator, was influential in organizing training and accessing outside resources, e.g. from local and provincial government, as well as bringing together and supporting local group leaders who would otherwise have been very isolated (in particular, farm leaders from remote T'boli settlements).

The key to understanding these developments lies in the distinction between bonding and bridging social capital, mentioned above. Typically, there was already a high level of bonding social capital in the local communities where landcare groups were formed – hence the ease of group formation. Forming a landcare group was a reflection of this initial stock of social capital rather than a means of generating greater local-level integration. For example, implementing contour barriers through small work groups was a natural extension of the system of labour exchange already in place in both indigenous and immigrant communities. The persistence of a group both reflected and reinforced the degree of trust and cooperation in these pre-existing social bonds.

However, forming or joining a landcare group also meant linking to a much wider network than provided by the local community. Hence it can be viewed primarily as an investment in bridging social capital. The bridges included horizontal linkages with progressive farmers in other localities through the municipal-wide landcare association, as well as vertical linkages with SEARCA and other outside agencies. (Some writers now make a conceptual distinction between such horizontal extra-community ties, which they term 'bridging social capital', and vertical ties, termed 'linking social capital'.) This dimension of landcare clearly augmented the stock of social capital in ways that provided significant benefits, both to members and non-members of community landcare groups (note that many farmers learned the new conservation practices directly from their neighbours). Hence the decline of local group activity often merely reflected a declining immediate need for that kind of activity (contouring, nursery establishment) but not a declining interest in the bridging social capital provided by the landcare network.

In some respects, the development of this bridging social capital actually undermined the bonding social capital encapsulated in the local groups, as predicted by Woolcock (1998). In particular, as members gained knowledge and experience in nursery management through the communal landcare nurseries, some preferred to develop private nurseries and pursue commercial outlets for their planting materials (a phenomenon that had occurred earlier in the landcare sites at Claveria and Lantapan). However, such individuals still valued the links to the Landcare Facilitator and the Association.

Ongoing investment to maintain and expand the stock of bridging social capital was clearly needed. In particular, the support of LGUs at the *barangay* and municipal levels that was evident in the Claveria Landcare Programme was not found to the same degree in Ned. This did not appear to have hindered landcare activities in the short term and may in fact have encouraged the Association leaders to organize, including the mobilization of political support. However, the presence of a strong facilitating institution (SEARCA) had been essential, offsetting the immediate need for partnership with LGUs. In the longer term, stronger links with an array of government and non-government agencies would be needed to sustain the Landcare Programme in Ned.

It can be concluded that the Landcare Programme had made a significant investment in livelihood resources, notably human and social capital, with the investment in social capital providing the necessary linkages for the adaptive research and farmer-to-farmer training activities that led to the growth of human capital. However, the outcomes of the Landcare Programme for both livelihood security and environmental sustainability were not as easy to establish. There was clear evidence that adoption of the recommended conservation practices had a significant impact on reducing soil erosion, hence on maintaining farmers' natural capital. The catchment-wide impacts remain to be investigated. Although these wider impacts are likely to have been positive, with only 16 per cent of the total cultivated area under conservation measures, the total impact is unclear. The impact on farm incomes was not obvious in the short term and was likely to be primarily a function of the changed cropping practices implemented on the contoured farms, that is, the diversification of livelihood activities. Farm budgets suggest that the expansion of tree crops will ultimately lead to a quantum jump in farm incomes, relative to merely maintaining maize yields. The full realization of these livelihood benefits will depend to a large degree on continuing investment in physical capital in the form of improved transport infrastructure, something that is beyond the scope of the Landcare Programme.

Conclusion

The study found that the Landcare Programme in Barangay Ned has been associated with rapid adoption of simple conservation farming practices, especially natural vegetative strips, and the rapid formation of local landcare groups and a *barangay*-wide landcare association. Such rapid adoption has not often been observed in the Philippine uplands. Using a sustainable rural livelihoods framework for the evaluation study helped to place these phenomena within the context of the agroecological and institutional changes that had been taking place in the preceding two decades, and the evolving livelihood strategies of rural households in Ned, particularly their interest in on-farm diversification to augment their meagre cash incomes. The most important effect of the Landcare Programme was to enhance the human capital of the farming population through practical, farmer-led training and extension, enabling farmers to incorporate soil conservation and agroforestry technologies in their farming systems, with desirable outcomes both for livelihood security and environmental sustainability. The social capital formed through the Programme, particularly the bridging social capital in the form of the Ned Landcare Association and its networks, was crucial to the growth in human capital. Nevertheless, ongoing investment was required to maintain and expand the stock of social capital for the longer term success of the Programme, including its capacity to be scaled up to embrace other localities.

The larger message from the study is that the promotion of conservation farming systems in fragile and impoverished upland environments requires an approach that embraces sustainable rural livelihoods, both for farm households and local communities, rather than narrowly focusing on the transfer of technology or the imposition of environmental regulations. While the availability of simple, well-adapted conservation practices is a key starting point, programme interventions such as the Landcare Programme that invest in human and social capital – thus building the capacity of farmers and farming communities to identify and pursue sustainable livelihood strategies – are essential to achieving the twin goals of rural development and environmental conservation. However, such farmer-led approaches still require ongoing partnerships with adequately resourced facilitating agencies, whether local government units or non-government organizations, or (preferably) both.

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14

Conserving Communities

Wendell Berry

In October of 1993, the *New York Times* announced that the United States Census Bureau would 'no longer count the number of Americans who live on farms'. In explaining the decision, the *Times* provided some figures as troubling as they were unsurprising. Between 1910 and 1920, we had 32 million farmers living on farms – about a third of our population. By 1950, this population had declined, but our farm population was still 23 million. By 1991, the number was only 4.6 million, less than 2 per cent of the national population. That is, our farm population had declined by an average of almost half a million people a year for 41 years. Also, by 1991, 32 per cent of our farm managers and 86 per cent of our farm workers did *not* live on the land they farmed.

These figures describe a catastrophe that is now virtually complete. They announce that we no longer have an agricultural class that is, or that can require itself to be, recognized by the government; we no longer have a 'farm vote' that is going to be of much concern to politicians. American farmers, who over the years have wondered whether or not they counted, may now put their minds at rest: they do not count. They have become statistically insignificant.

We must not fail to appreciate that this statistical insignificance of farmers is the successful outcome of a national purpose and a national programme. It is the result of great effort and of principles rigorously applied. It has been achieved with the help of expensive advice from university and government experts, by the tireless agitation and exertion of the agribusiness corporations, and by the renowned advantages of competition – of our farmers among themselves and with farmers of other countries. As a result, millions of country people have been liberated from farming, landownership, self-employment and other idiocies of rural life.

But what has happened to our agricultural communities is not exceptional any more than it is accidental. This is simply the way a large, exploitive, absentee economy works. For example, here is a *New York Times* News Service report on 'rape-and-run' logging in Montana:

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> Throughout the 1980s, the Champion International Corp. went on a tree-cutting binge in Montana, leveling entire forests at a rate that had not been seen since the cut-and-run logging days of the last century.
>
> Now the hangover has arrived. After liquidating much of its valuable timber in the Big Sky country, Champion is quitting Montana, leaving behind hundreds of unemployed mill workers, towns staggered by despair and more than 1,000 square miles of heavily logged land.

The article goes on to speak of the revival of 'a century-old complaint about large, distant corporations exploiting Montana for its natural resources and then leaving after the land is exhausted'. And it quotes a Champion spokesman, Tucker Hill, who said: 'We are very sympathetic to those people and very sad. But I don't think you can hold a company's feet to the fire for everything they did over the last twenty years.'

If you doubt that exhaustion is the calculated result of such economic enterprise, you might consider the example of the mountain counties of eastern Kentucky from which, over the last three-quarters of a century, enormous wealth has been extracted by the coal companies, leaving the land wrecked and the people poor.

The same kind of thing is now happening in banking. In the county next to mine an independent local bank was recently taken over by a large out-of-state bank. Suddenly some of the local farmers and small-business people, who had been borrowing money from that bank for 20 years and whose credit records were good, were refused credit because they did not meet the requirements of a computer in a distant city. Old and once-valued customers now find that they are known by category rather than character. The directors and officers of the large bank clearly have reduced their economic thinking to one very simple question: 'Would we rather make one big loan or many small ones?' Or to put it only a little differently: 'Would we rather support one larger enterprise or many small ones?' And they have chosen the large over the small.

This economic prejudice against the small has, of course, done immense damage for a long time to small or family-sized businesses in city and country alike. But this prejudice has often overlapped with an industrial prejudice against anything rural and against the land itself, and this prejudice has resulted in damages that are not only extensive but also long-lasting or permanent.

As we all know, we have much to answer for in our use of this continent from the beginning, but in the last half-century we have added to our desecrations of nature a deliberate destruction of our rural communities. The statistics I cited at the beginning are incontrovertible evidence of this. But so is the condition of our farms and forests and rural towns. If you have eyes to see, you can see that there is a limit beyond which machines and chemicals cannot replace people; there is a limit beyond which mechanical or economic efficiency cannot replace care.

I am talking here about the common experience, the common fate, of rural communities in our country for a long time. It has also been, and it will increasingly be, the common fate of rural communities in other countries. The message is plain enough, and we have ignored it for too long: the great, centralized economic entities of our time do not come into rural places in order to improve them by 'creating jobs'. They come to take as much of value as they can take, as cheaply and as quickly as they can take it. They are interested in 'job creation' only so long as the jobs can be done more cheaply by humans than by machines. They are not interested in the good health – economic or natural or human – of any place on this Earth. And if you should undertake to appeal or complain to one of these great corporations on behalf of your community, you would discover something most remarkable: you would find that these organizations are organized expressly for the evasion of responsibility. They are structures in which, as my brother says, 'the buck never stops'. The buck is processed up the hierarchy until finally it is passed to 'the shareholders', who characteristically are too widely dispersed, too poorly informed and too unconcerned to be responsible for anything. The ideal of the modern corporation is to be (in terms of its own advantage) anywhere and (in terms of local accountability) nowhere. The message to country people, in other words, is this: Don't expect favours from your enemies.

And that message has a corollary that is just as plain and just as much ignored: the governmental and educational institutions from which rural people should by right have received help have not helped. Rather than striving to preserve the rural communities and economies and an adequate rural population, these institutions have consistently aided, abetted and justified the destruction of every part of rural life. They have eagerly served the superstition that all technological innovation is good. They have said repeatedly that the failure of farm families, rural businesses and rural communities is merely the result of progress and efficiency and is good for everybody.

We are now pretty obviously facing the possibility of a world that the supranational corporations, and the governments and educational systems that serve them, will control entirely for their own enrichment – and, incidentally and inescapably, for the impoverishment of all the rest of us. This will be a world in which the cultures that preserve nature and rural life will simply be disallowed. It will be, as our experience already suggests, a postagricultural world. But as we now begin to see, you cannot have a postagricultural world that is not also postdemocratic, postreligious, postnatural – in other words, it will be posthuman, contrary to the best that we have meant by 'humanity'.

In their dealings with the countryside and its people, the promotors of the so-called global economy are following a set of principles that can be stated as follows. They believe that a farm or a forest is or ought to be the same as a factory; that care is only minimally necessary in the use of the land; that affection is not necessary at all; that for all practical purposes a machine is as good as a human; that the industrial standards of production, efficiency and profitability are the only standards that are necessary; that the topsoil is lifeless and inert; that soil biology is safely replaceable by soil chemistry; that the nature or ecology of any given place is irrelevant to the use of it; that there is no value in human community or neighbourhood; and that technological innovation will produce only benign results.

These people see nothing odd or difficult about unlimited economic growth or unlimited consumption in a limited world. They believe that knowledge is property and is power, and that it ought to be. They believe that education is job training. They think that the summit of human achievement is a high-paying job that involves no work. Their public boast is that they are making a society in which everybody will be a 'winner' – but their private aim has been to reduce radically the number of people who, by the measure of our historical ideals, might be thought successful: the independent, the self-employed, the owners of small businesses or small usable properties, those who work at home.

The argument for joining the new international trade agreements has been that there is going to be a one-world economy, and we must participate or be left behind – though, obviously, the existence of a one-world economy depends on the willingness of all the world to join. The theory is that under the rule of international, supposedly free, trade products will naturally flow from the places where they can be best produced to the places where they are most needed. This theory assumes the long-term safety and sustainability of massive international transport, for which there are no guarantees, just as there are no guarantees that products will be produced in the best way or to the advantage of the workers who produce them or that they will reach or can be afforded by the people who need them.

There are other unanswered questions about the global economy, two of which are paramount: How can any nation or region justify the destruction of a local productive capacity for the sake of foreign trade? and How can people who have demonstrated their inability to run national economies without inflation, usury, unemployment and ecological devastation now claim that they can do a better job in running a global economy? American agriculture has demonstrated by its own ruination that you cannot solve economic problems just by increasing scale and, moreover, that increasing scale is almost certain to cause other problems – ecological, social and cultural.

We can't go on too much longer, maybe, without considering the likelihood that we humans are not intelligent enough to work on the scale to which we have been tempted by our technological abilities. Some such recognition is undoubtedly implicit in American conservatives' long-standing objection to a big central government. And so it has been odd to see many of these same conservatives pushing for the establishment of a supranational economy that would inevitably function as a government far bigger and more centralized than any dreamed of before. Long experience has made it clear – as we might say to the liberals – that to be free we must limit the size of government and we must have some sort of home rule. But it is just as clear – as we might say to the conservatives – that it is foolish to complain about big government if we do not do everything we can to support strong local communities and strong community economies.

But in helping us to confront, understand and oppose the principles of the global economy, the old political alignments have become virtually useless. Communists and capitalists are alike in their contempt for country people, country life and country places. They have exploited the countryside with equal greed and disregard. They are alike even in their plea that it is right to damage the present in order to make 'a better future'.

The dialogue of Democrats and Republicans or of liberals and conservatives is likewise useless to us. Neither party is interested in farmers or in farming or in the good care of the land or in the quality of food. Nor are they interested in taking the best care of our forests. The leaders of these parties are equally subservient to the supranational corporations. Of this the North American Free Trade Agreement and the new revisions to the General Agreement on Tariffs and Trade are proof.

Moreover, the old opposition of country and city, which was never useful, is now more useless than ever. It is, in fact, damaging to everybody involved, as is the opposition of producers and consumers. These are not differences but divisions that ought not to exist because they are to a considerable extent artificial. The so-called urban economy had been just as hard on urban communities as it has been on rural ones.

All these conventional affiliations are now meaningless, useful only to those in a position to profit from public bewilderment. A new political scheme of opposed parties, however, is beginning to take form. This is essentially a two-party system, and it divides over the fundamental issue of community. One of these parties holds that community has no value; the other holds that it does. One is the party of the global economy; the other I would call simply the party of local community. The global party is large, though not populous, immensely powerful and wealthy, self-aware, purposeful and tightly organized. The community party is only now becoming aware of itself; it is widely scattered, highly diverse, small though potentially numerous, weak though latently powerful and poor though by no means without resources.

We know pretty well the makeup of the party of the global economy, but who are the members of the party of local community? They are people who take a generous and neighbourly view of self-preservation; they do not believe that they can survive and flourish by the rule of dog eat dog; they do not believe that they can succeed by defeating or destroying or selling or using up everything but themselves. They doubt that good solutions can be produced by violence. They want to preserve the precious things of nature and of human culture and pass them on to their children. They want the world's fields and forests to be productive; they do not want them to be destroyed for the sake of production. They know you cannot be a democrat (small *d*) or a conservationist and at the same time a proponent of the supranational corporate economy. They believe – they know from their experience – that the neighbourhood, the local community, is the proper place and frame of reference for responsible work. They see that no commonwealth or community of interest can be defined by greed. They know that things connect – that farming, for example, is connected to nature, and food to farming, and health to food – and they want to preserve the connections. They know that a healthy local community cannot be replaced by a market or an entertainment industry or an information highway. They know that contrary to all the unmeaning and unmeant political talk about 'job creation', work ought not to be merely a bone thrown to the otherwise unemployed. They know that work ought to be necessary; it ought to be good; it ought to be satisfying and dignifying to the people who do it, and genuinely useful and pleasing to the people for whom it is done.

The party of local community, then, is a real party with a real platform and an agenda of real and doable work. And it has, we might add, a respectable history in the hundreds of efforts, over several decades, to preserve local nature or local health or to sell local products to local consumers. Now such efforts appear to be coming into their own, attracting interest and energy in a way they have not done before. People are seeing more clearly all the time the connections between conservation and economics. They are seeing that a community's health is largely determined by the way it makes its living.

The natural membership of the community party consists of small farmers, ranchers and market gardeners, worried consumers, owners and employees of small shops, stores, community banks and other small businesses, self-employed people, religious people and conservationists. The aims of this party really are only two: the preservation of ecological diversity and integrity, and the renewal, on sound cultural and ecological principles, of local economies and local communities.

So now we must ask how a sustainable local community (which is to say a sustainable local economy) might function. I am going to suggest a set of rules that I think such a community would have to follow. And I hasten to say that I do not consider these rules to be predictions; I am not interested in foretelling the future. If these rules have any validity, it is because they apply now.

If the members of a local community want their community to cohere, to flourish and to last, these are some things they would do:

1 Always ask of any proposed change or innovation: What will this do to our community? How will this affect our common wealth?
2 Always include local nature – the land, the water, the air, the native creatures – within the membership of the community.
3 Always ask how local needs might be supplied from local sources, including the mutual help of neighbours.
4 Always supply local needs *first*. (And only then think of exporting, first to nearby cities and then to others.)
5 Understand the unsoundness of the industrial doctrine of 'labour saving' if that implies poor work, unemployment or any kind of pollution or contamination.
6 Develop properly scaled value-adding industries for local products to ensure that the community does not become merely a colony of the national or global economy.
7 Develop small-scale industries and businesses to support the local farm and/or forest economy.
8 Strive to produce as much of the community's own energy as possible.
9 Strive to increase earnings (in whatever form) within the community and decrease expenditures outside the community.

10 Make sure that money paid into the local economy circulates within the community for as long as possible before it is paid out.
11 Make the community able to invest in itself by maintaining its properties, keeping itself clean (without dirtying some other place), caring for its old people, teaching its children.
12 See that the old and the young take care of one another. The young must learn from the old, not necessarily and not always in school. There must be no institutionalized ‘child care’ and ‘homes for the aged’. The community knows and remembers itself by the association of old and young.
13 Account for costs now conventionally hidden or ‘externalized’. Whenever possible, these costs must be debited against monetary income.
14 Look into the possible uses of local currency, community-funded loan programmes, systems of barter and the like.
15 Always be aware of the economic value of neighbourly acts. In our time the costs of living are greatly increased by the loss of neighbourhood, leaving people to face their calamities alone.
16 As a rural community, always be acquainted with, and complexly connected with, community-minded people in nearby towns and cities.
17 Formulate an economy that will always be more cooperative than competitive, for a sustainable rural economy is dependent on urban consumers loyal to local products.

These rules are derived from Western political and religious traditions, from the promptings of ecologists and certain agriculturists and from common sense. They may seem radical, but only because the modern national and global economies have been formed in almost perfect disregard of community and ecological interests. A community economy is not an economy in which well-placed persons can make a ‘killing’. It is not a killer economy. It is an economy whose aim is generosity and a well-distributed and safeguarded abundance. If it seems unusual to hope and work for such an economy, then we must remember that a willingness to put the community ahead of profit is hardly unprecedented among community businesspeople and local banks.

How might we begin to build a decentralized system of durable local economies? Gradually, I hope. We have had enough of violent or sudden changes imposed by predatory interests outside our communities. In many places, the obvious way to begin the work I am talking about is with the development of a local food economy. Such a start is attractive because it does not have to be big or costly, it requires nobody’s permission and it can ultimately involve everybody. It does not require us to beg for mercy from our exploiters or to look for help where consistently we have failed to find it. By ‘local food economy’ I mean simply an economy in which local consumers buy as much of their food as possible from local producers and in which local producers produce as much as they can for the local market.

Several conditions now favour the growth of local food economies. On the one hand, the costs associated with our present highly centralized food system are going to increase. Growers in the Central Valley of California, for example, can no longer depend on an unlimited supply of cheap water for irrigation. Transportation costs can only go up. Biotechnology, variety patenting and other agribusiness innovations are intended not to help farmers or consumers but to extend and prolong corporate control of the food economy; they will increase the cost of food, both economically and ecologically.

On the other hand, consumers are increasingly worried about the quality and purity of their food, and so they would like to buy from responsible growers close to home. They would like to know where their food comes from and how it is produced. They are increasingly aware that the larger and more centralized the food economy becomes, the more vulnerable it will be to natural or economic catastrophe, to political or military disruption and to bad agricultural practice.

For all these reasons, and others, we need urgently to develop local food economies wherever they are possible. Local food economies would improve the quality of food. They would increase consumer influence over production; consumers would become participatory members in their own food economy. They would help to ensure a sustainable, dependable supply of food. By reducing some of the costs associated with long supply lines and large corporate suppliers (such as packaging, transportation and advertising), they would reduce the cost of food at the same time that they would increase income to growers. They would tend to improve farming practices and increase employment in agriculture. They would tend to reduce the size of farms and increase the number of owners.

Of course, no food economy can be, or ought to be, *only* local. But the orientation of agriculture to local needs, local possibilities and local limits is indispensable to the health of both land and people, and undoubtedly to the health of democratic liberties as well.

For many of the same reasons, we need also to develop local forest economies, of which the aim would be the survival and enduring good health of both our forests and their dependent local communities. We need to preserve the native diversity of our forests as we use them. As in agriculture, we need local, small-scale, non-polluting industries (sawmills, woodworking shops and so on) to add value to local forest products, as well as local supporting industries for the local forest economy.

Just as support for sustainable agriculture should come most logically from consumers who consciously wish to keep eating, so support for sustainable forestry might logically come from loggers, mill workers and other employees of the forest economy who consciously wish to keep working. But *many* people have a direct interest in the good use of our forests: farmers and ranchers with woodlots, all who depend on the good health of forested watersheds, the makers of wood products, conservationists and others.

What we have before us, if we want our communities to survive, is the building of an adversary economy, a system of local or community economies within, and to protect against, the would-be global economy. To do this, we must somehow learn to reverse the flow of the siphon that has for so long been drawing resources, money, talent and people out of our countryside with very little if any return, and often with a return only of pollution, impoverishment and ruin. We must figure out new ways to fund, at affordable rates, the development of healthy local economies. We must find ways to suggest economically – for finally no other suggestion will be effective – that the work, the talents and the interest of our young people are needed at home.

Our whole society has much to gain from the development of local land-based economies. They would carry us far toward the ecological and cultural ideal of local adaptation. They would encourage the formation of adequate local cultures (and this would be authentic multiculturalism). They would introduce into agriculture and forestry a sort of spontaneous and natural quality control, for neither consumers nor workers would want to see the local economy destroy itself by abusing or exhausting its sources. And they would complete at last the task of gaining freedom from colonial economics, begun by our ancestors more than 200 years ago.

15

Becoming an Agroecologist Through Action Education

Geir Lieblein, Edvin Østergaard and Charles Francis

Introduction

Education in agroecology (Francis et al, 2003), agricultural systems and sustainable agriculture can provide students with a broad curriculum that deals with the interaction among production, economic, environmental and social dimensions of farming and food systems. Courses in agroecology and organic farming are becoming more prevalent on university campuses in the Nordic region, Europe, US and elsewhere (Sriskandarajah et al, 2005). Yet we observe that in most programmes and courses the teaching methods have departed little from a strong emphasis on transmitting information through lectures, some discussion and library readings, and periodic trips to farms that often turn into lectures in the field.

The predominance of lectures and narrowly focused courses are used in many agriculture and food system curricula as an accepted and even expected approach to education that fits into the comfort zones of both teacher and student. The majority of university teachers are specialists in research disciplines in science where they did graduate study, and few have experienced formal courses in educational history and theory. They are unfamiliar with the tenets of John Dewey's admonition that learning should not be authoritarian, but should begin with the experience of the individual students (Dewey, 1916).

Even teachers in agriculture who are not versed in the education literature will identify with Mezirow's (2000) thesis that the way in which we build understanding around a specific context often reflects our initial assumptions. We have more difficulty dealing with his conclusion that there are no fixed truths nor definitive knowledge, though a growing appreciation of the complexity of farming and food systems is leading us as agricultural scientists in that direction. Mezirow's transformation theory helps us understand how important it is to become aware of our assumptions and expectations, and to adjust those to the students or farmers we

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work with in the educational arena. Mezirow emphasized the need to critically reflect on the assumptions and beliefs that shape practice, and proposed that such reflection can transform our knowledge. We can then appreciate how these assumptions can filter our experiences as well as our awareness and understanding of what we observe, much as Kuhn (1962) describes the adherence to a dominant paradigm in each field of study.

Boud et al (1993) emphasize the importance of how learning occurs in many places, and how this shapes our total experience and our lives. We learn to deal with complexities of systems, our own and others' personal commitments and the emotions and feelings that help shape each 'learning landscape'. In line with John Dewey, Boud and colleagues emphasize that (1) experience is the foundation for learning, (2) learners actively construct their experience, (3) the process is inherently holistic, (4) learning is socially and culturally constructed, and (5) the entire educational process is strongly influenced by the socio-emotional context in which it occurs.

We have taken these lessons to heart in design of the Nordic region programme in Agroecology (Francis et al, 2001; Lieblein et al, 1999, 2001a, 2001b) and an Agroecosystems Analysis course in the US Midwest (Wiedenhoeft et al, 2003) that both feature action and participation-based learning. An allied term used for education that moves students onto the farm and into the community to deal with people and challenges in real-life situations is 'service learning' (Benson and Harkavy, 2000; Pollack, 1999), where students go beyond observation and become proactive in community change.

In the Nordic and Midwest programmes, teachers and students share the responsibility for learning. Faculty act as guides or learning leaders to organize an educational environment or 'learning landscape' where it is conducive and safe to explore and discover. The field is broadened from focus on the teacher to also encompass the students and their experiences. Maximum attention is placed on the process of learning, or learning how to learn, rather than on the specific content that is transitory and often outdated by the time it reaches the classroom. In addition to the knowledge goals that are the focus of most university programmes, we bring attention to the skills and attitudes that people have toward the material, and to their potential for visioning into the future. Our primary goal is to nurture the development of autonomous graduates who are prepared to deal with complexity and change, rather than continuing to focus on the curriculum and on what we can prepare and present in the confines of the classroom. As organizers of this learning landscape, we can prepare the next generation of agroecologists to deal effectively with a rapidly changing and undefined future.

In this article we use action learning in its broadest sense: learning through action (McGill and Beaty, 2001). Action learning draws upon the works of Reg Revans (1998), who coined the term, as well as on experiential learning (Dewey, 1916; Kolb, 1984) and critical reflection (Mezirow, 2000). Through action learning, students and teachers learn with and from each other by working together to improve real situations, and by reflecting on their own experiences (McGill and Beaty, 2001).

From Teaching to Learning

One important reason for students to come to the university is to learn something they did not know. There are many dedicated teachers with broad appreciation of what is important, yet some topics may be chosen because they are the research specialties of teachers with narrow research or personal interests. We generally call ourselves teachers, and we really focus on doing teaching very well. Every university has teaching appointments, teaching evaluations and teaching awards. There is an implicit assumption that when we teach, someone will learn. In fact some of us have learned the importance of agroecology and the whole farm and food systems from within the conventional educational structures and integrated this with unique experiences achieved by farmers and others in the world outside academia.

Our Nordic and Midwest agroecology groups strongly believe that we can make more progress through an explicit focus on students and on their learning rather than by fine-tuning classroom methods or the improved organization of a curriculum to fit our time-honoured beliefs in the importance of a certain list of basic and applied courses. This shift is in accordance with the direction of current pedagogical discourses and didactical thinking (Bawden et al, 2000; McGill and Beaty, 2001).

'Just in time education' is a concept that we are exploring for the sequencing of courses in the university curriculum (Salomonsson et al, 2005). Instructors and advisors in the Swedish Agricultural University observed that many students were postponing a required first-year chemistry class until their fourth or even fifth year of study. Careful questioning of students about why they made this decision revealed that many were unsure of how and why they were studying chemistry, except that it was a requirement. Other students were ready for the course in their first year, but many did not understand the context nor had they experienced the need for that information. During their fourth or fifth years, these latter students realized the need for such a course, and it was 'just in time' for them to take it at this stage. When the focus is on learning, we provide opportunities for students to enrol in courses that they find the most purposeful. This does not eliminate the need for thoughtful advising by teachers, who can guide students through the learning landscape to find those courses that will best help them gain the experience and skills that they will need to meet their individual long-term objectives.

Focus on Action Learning

Learning through action and for action is a perspective which is drawn out of Dewey's experience-based learning. According to Dewey, education and upbringing of children is life, and life itself is human growth and development: 'Since growth is the characteristic of life, education is all one with growing; it has no end beyond itself' (Dewey, 1916). His basic idea, learning by doing *and* reflecting, points at our experiences and activities in the world as starting points for learning. Reflective practice, which is so important for professional development, is, however, not an automatic result of experience, since doing does not necessarily lead to learning. It is then the task of the teacher to intentionally facilitate for a situation where learning based on lived experience can take place (van Manen, 1990). It is the task of the teacher to create a genuine situation for experience, which means that the learning of theoretical knowledge has to build on the students' own experience.

The basic principle of action learning is that learning and acting in the world is one and the same thing. As Argyris and Schön (1974, p4) state, 'all human beings, not only professional practitioners, need to become competent in taking action and simultaneously reflect on this action to learn from it'. Learning is thus a process of reflecting on actions in the world, as they appear in one's own experience. In recent years several other pedagogical methods have risen from these basic ideas of Dewey, as experiential learning (Bawden et al, 2000; Kolb, 1984) and problem-based learning (Barrows, 1985, 1986). According to situated learning (Lave and Wenger, 1990), learning as it normally occurs is a function of the activity, context and culture in which it is situated. The theory of situated learning states that in order to achieve a good learning situation, knowledge needs to be present in a socially and culturally authentic context.

In accordance with the findings of Pfeffer (1998), we have observed over many years of dealing with students in the university that there is often a larger gap between knowledge and action than there is between ignorance and knowledge. This is not to endorse ignorance nor to minimize the importance of students expanding their knowledge base, but rather to achieve a compromise that shifts the balance away from total reliance on gaining knowledge to a new balance that puts emphasis on applications. Students may have knowledge and skills, but not an understanding of how to apply the knowledge to real life situations. Most education programmes are designed to add more knowledge and a few specialized skills to what students have already acquired from prior schooling. To be sure, it is important to know how to take soil samples or to recognize weeds in the field, as well as understand how to translate soil analyses or weed counts into recommendations for soil-fertility additives or methods of weed control. But we find that this is not sufficient.

Bringing to attention attitudes toward the environment, and the rural clients with whom we work, is essential in putting knowledge to work. As teachers we obviously display our values, our attitudes and our passions about certain topics to the students, and this is one of the joys of teaching. But this is quite different than only teaching about our own attitudes or forcing a specific point of view. Rather it demonstrates the importance of recognizing attitudes and values as part of education and it is therefore essential for each student to examine their own. This step can bring them closer to action, because they experience that actions made to better the human situation are necessarily grounded in values and attitudes, and that their own actions have a similar grounding.

Another important dimension of education is learning the power of visioning. In the quest for sustainable development, it is not enough to have knowledge and abilities to review the past and analyse the present. In addition, it is vital to have competencies in designing the future. Visionary thinking has a key role in building future-oriented competencies. In accordance with Parker (1990, pp1–2), we see visions as:

> powerful mental images of what we want to create in the future. They reflect what we care about the most, and are harmonious with our values and sense of purpose. Visions are the product of insight, values and imagination, they are the head and the heart working together.

According to Senge (1990), shared vision at its simplest level is the answer to the question, 'What do we want to create?' Visionary thinking, introduced through a three-day seminar for the MSc students, has played a key role in our agroecological education at the Norwegian University for Life Sciences over the past six years. Students value this approach, since developing a coherent view of a potential and desirable future enables them to integrate their diverse case experiences. It also allows them to use the creative sides of their personalities, establishing a bridge from analysing the past and present to start thinking about actions to move from the present to the future desired situation (Lieblein et al, 2001).

Key Characteristics of Agroecological Education

Real life phenomena as the foundation for learning

In contrast to a conventional course where the first lecture describes the history and foundation of that discipline, in the agroecology courses real life phenomena are established as the starting point for the learning process. Rather than agroecological theory having primary value, we immerse students in practical phenomena at the farming and food system levels, and let these phenomena determine what theory is necessary and relevant. We place high value on incorporating students' lived experiences (van Manen, 1990), and reject the mystification of the experiences of everyday life. We think that real life phenomena provide the necessary foundation for inter- and trans-disciplinary activities, because they provide a common language between and among the traditional disciplines. Inductive learning is therefore the preferred basic mode of learning. Agroecology as such is not only a specific body of theory, but it also involves a meaningful way of dealing with complex phenomena in farming and food systems, with the goal to improve those systems. Through such an understanding of agroecology, its two related dimensions become clear: agroecology as a set of theories and as a set of abilities.

Inclusion of divergent modes of learning

We further explicitly introduce the divergent mode of thinking and sharing experience early in the learning process. The process of convergence has been overemphasized as an analytical approach within academia, as opposed to a more innovative, divergent and unstructured mode of thinking and creating meaning. The balance between these two modes of thinking needs to be restored, and the interface between the two needs to be encouraged and expanded. In line with this we critically and creatively need to consider the whole range of possible pedagogical interventions to be able to meet the diverse needs of students, who come with different learning styles and different personal and cultural experiences.

Students as the focus of education

One key principle in our planning and implementing the agroecology courses is that the student is placed in the centre of the activities. In other words, rather than looking at agroecology as a subject matter or discipline, we are concerned about the agroecologist. Thus, the primary goal is not to understand or analyse the agroecosystem, but rather to develop oneself as someone who puts agroecology into practice. More than a discussion about what is the necessary theory to cover is the exploration of what knowledge, skills, attitudes and capacities for visioning we consider important for the agroecologist to have to become an agent of change for sustainable development.

Explicit recognition of student contributions

In line with placing the student in the centre of the programme, we are geared towards learning activities that celebrate and build on contributions from individual students. In this process, 'the inside of the individual is brought out', rather than a one-way information transmission that assumes that the mind of the student is an empty vessel to be filled with theory, 'bringing the outside in'. We see this as an important prerequisite for developing the proactive capacities of students, to enable them to become agents of change. Examples of activities in the courses to build these skills are developing rich pictures of complex situations, mind mapping, dialogue, creative problem solving and visionary thinking. These are all activities driven by students and guided by teachers.

New Roles in Education

Systems- and action-oriented learning implies new roles for all involved in the education of agroecologists. As already stated, the main challenge is to link the subject matter of agroecology, with its interdisciplinary and holistic character, to the students' learning. Our approach, in accordance with action learning and experiential learning, has been to start with the experiences of the students, but not in a fundamentalist sense. As such we see the merging interest in action learning as a reaction to the traditional teaching and theory-based education. This swings the pendulum to the opposite extreme from where the focus is on the theories of the teacher. This has been a necessary shift of focus in education, but the sole application of experiences as a basis for learning has its limitations, and if pursued too far it becomes fundamentalist. The problem is that not all learning is based on our experiences: we also learn from others in a social setting (Bandura, 1977), from the culture in which we are embedded (Lave and Wenger, 1990), but also from theory that may come through a good lecture or a good book. The challenge is to blend many different approaches to meet the needs of many different students. Also, in a strict phenomenological sense, the diversity of real life phenomena needs to be met by a diversity of learning modes. It has been important for us not to go completely from the traditional theory-based teaching to the new practice-based experiences in one large leap, but to widen the field of learning for the students. They should be able to go deep into theory and then deep into practice.

When the focus shifts from teacher to student all parties involved have to find their new roles within the educational system. Lieblein and Østergaard (2001) have called this a 'pedagogy of no mercy', because the feedback becomes especially clear and explicit. The real challenge in a 'pedagogy of no mercy' is that changing from lecturing to improving the students' learning implies losing the control of the learning situation. Through this process the teachers' role changes; the teachers still have the responsibility for the overall learning process, as learning leaders, but also become co-learners together with the students. The students are no longer receivers of knowledge, but have a new role as learners, and their learning involves more than cognition. What the students experience also involves notions, emotions and attitudes. Their learning becomes competency oriented, involving knowledge, skills, attitudes and potential for visioning. Their goals are no longer to uncover answers already known by the teachers or written in textbooks; instead, teachers and students will engage in a joint process to learn about complex real life situations (Francis et al, 2001). The shift from knowledge to competency orientation also implies the shift from a focus on agroecology to the process of becoming an agroecologist. The focus on knowledge is very often connected to the input–output model of knowledge transfer. The competency orientation must on the other hand be related to developing and improving skills through a mutual relation – between the students, between the students and the stakeholders 'out there' and between the students and the teachers.

In this process the roles of theory and practice also change: practice is no longer just used as an example of theories lectured in the classroom, but is used as the starting point for learning. And theory is no longer the focal part of the education, but is seen as something that should support the learners in their development.

Focus on Becoming an Agroecologist

Students embrace a certain field of study because they are motivated, hopefully even passionate, about learning new things and putting them into action. Whatever we do in designing the educational landscape should serve to promote and fulfil that passion, rather than stifling it. An example from classical medical schools is appropriate. The conventional curriculum involved heavy first- and second-year courses in anatomy, learning the Latin names of hundreds of muscles and bones, and this often served as a screening tool to eliminate many who were not capable of, or interested in, such rote learning. Successful memorizers became the specialists who dominate today's medical profession. Some students dropped out because they were bored with material that was important, to be sure, but far from the contacts with real patients that they anticipated. The courses did not fulfill their desire to help people that generated their passion in the first place.

The University of Tromsø in Norway and the Oregon Health Sciences Hospital in the US pioneered the mentoring approach that put medical students into white coats with name badges and stethoscopes right from the first week in school. They took patient histories, made preliminary diagnoses and shadowed mentor doctors for one day each week, thus reinforcing their passion for dealing with people in need. This new and practical approach prevented the unnecessary early screening out of some of the best future doctors with a strong social conscience who may not have been the top academic students based on memorizing bones and muscle names. These potential future caring physicians often despaired of ever seeing patients, and it is likely that we have lost many candidates who could have become the best general practitioners. The new system seems to be working, and it is spreading to other medical schools.

So rather than focus on the time-honoured curriculum, continuing to teach courses in the sequence in which they have always been taught to all students, we should focus on what we want to achieve – a well prepared, knowledgeable, confident graduate in agroecology. We can focus on students and on learning, rather than on teachers and on teaching. We can design learning landscapes and environments that put the joy of discovery into learning, and can put shared responsibility for learning on teachers and students. The schedule and content of classes can include learning skills and new knowledge as well as clarification of attitudes toward the material and potential for visioning the future wanted situation (Schneider et al, 2005).

The strategy described here for planning educational experiences in agroecology is completely focused on who will complete the course of study, how they will put knowledge into action and what they will do when they leave the programme. We call this action education. Students observe and evaluate, and join the faculty in visiting farms, interviewing farmers and families and learning the broad context of the farm situation. The skilled agroecologists graduating from the programme will:

- Have knowledge of farming and food systems.
- Be able to handle complexity and change.
- Be able to link theory to real life situations.
- Be good communicators and facilitators.
- Be autonomous learners.

These competencies are not only vital for dealing with agroecological issues. They are key qualifications (Kämäräinen et al, 2002), which implies that they are transferable; the achieved skills are not limited to an agroecological context, but can be practiced in other parts of life. Agroecology and sustainable agriculture are good places for training these skills. Such skills will be vital to proactively deal with the challenges of specialization, high technology and use of non-renewable resources in modern society in the quest for a sustainable development.

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Part IV

Enabling Policies and Institutions for Sustainable Agricultural and Food Systems

16

A New Practice: Facilitating Sustainable Agriculture

Niels G. Röling and M. Annemarie E. Wagemakers

When Greenland Became White

How did our ancestors manage their environment? A green history of the world (Ponting, 1991) and the first conference on how pre-industrial civilizations coped with climate change (Pain, 1994) offer plausible insights.

One case study presented at the conference concerns the medieval Norse settlements in Greenland. Their agriculture prospered during the 12th century. In 1127, they sent a live polar bear to the Nordic King and received a bishop in return. But by 1500, Greenland had become white, and the only people still living there were the Inuit seal hunters. All that remains of the Norse communities are the ruins of their churches.

A comparative analysis of the strategies of the communities of the two peoples for coping with the Small Ice Age reveals that the Norsemen were more concerned with providing for their bishops and building churches than with changing their way of life or agriculture to accommodate the harsher climate. They persisted in trying to graze their cattle on increasingly poor grassland. The Inuit, however, adapted and developed their hunting and fishing in ways that allowed them to survive through the increasing cold.

Though it seems, at first, that the demise of the Greenlanders was caused by climate change, closer scrutiny reveals that the climate was not the only factor.

> By the time the temperature had plummeted in the 1370s, the productivity of the land was falling because of overgrazing and soil erosion. But while the Inuit adopted appropriate technologies of hunting and fishing, the Norse farmers – constrained by their rigidly ordered society and Christian culture – tried to maintain the way of life they were used to. They failed (Pain, 1994).

From this, and other cases presented during the conference, the following conclusions emerge:

- It is not so much climate change that causes problems, but entrenched modes of adapting to change. 'The ability and willingness of society to respond to changing conditions are the crucial conditions in determining whether it survives' (Pain, 1994).
- Such responsiveness depends on individual and collective choices, which are, of necessity, shaped by the past. This makes us vulnerable to discontinuous events for which there are no historical precedents.
- The development and use of knowledge is our main mechanism for survival in conditions of rapid change. That is, adaptation to changing conditions depends on perceiving and interpreting the signs of impending change, and on the timely development of knowledge, technology and organization in reaction to those signs. Thus, the adaptative response also demands creativity and inventiveness and a capacity for collective learning and innovation.
- By virtue of their privileged position, the elites who have a formal or social mandate to provide leadership are often shut off from direct or even indirect experience of the signs of change. They have the power to maintain their lifestyles and the way things are when it is no longer prudent to do so.

Are we like the Norsemen on Greenland?

About this Book

The question could imply that this book is about the Apocalypse, but nothing would be further from the truth. This book is about developing appropriate responses to environmental uncertainty and discontinuity. If anything, its authors are possibly too optimistic in their expectation that it is not beyond human society to make the adaptations that now appear necessary. That does not mean, of course, that we are convinced that meaningful and timely change will come about, but we hope that this book will increase the likelihood that it will.

The more specific aims of the book are to 'capture a new practice'; that is, to examine a number of cases of attempts to make farming more sustainable in conditions of uncertainty. Second, the contributors tease out the lessons of emerging practice with respect to the kinds of learning, facilitation, supporting institutions and conducive policy contexts that are required. The book's central questions therefore are: can we learn our way to a more sustainable agriculture? And if so, what does it take?

The case studies suggest that the answer to the first question is 'Yes'!, but also, that it will take a transformation of our epistemology, our technological and organizational practices, our ways of learning, our institutional frameworks and our policies. Such transformations do not come easy, and the question 'Are we

Norsemen on Greenland?' remains unanswered now that we have finished the book, but we have become a little clearer about the effort that needs to be made and we feel heartened by that understanding.

A Social Science Perspective

This book approaches sustainable farming from the point of view of social science. Hence its central focus is the human actor, and not the biophysical processes occurring in the agroecosystem (see Box 16.1). As you will see later, this has important implications for the way we define sustainability. It also means that this book does not deal in detail with the agronomic or other practices that are needed for using

Box 16.1 *The area of discourse of this book*

1		2		3		4
farm	↔	farmer	↔	facilitator	↔	etc.

The relationship between farmer and farm (1) is that of a human being dealing with biophysical resources and processes. Natural science supports the technologies and interventions used by the farmer to make the biophysical environment yield desired outcomes. These 'technical' aspects do not constitute the area of discourse of this book.

But change in relationship 1 is only possible if the farmer him/herself engages in learning (2). The learning process lies at the heart of this book. As we shall see, the transformation to sustainable agriculture requires a fundamental change in learning processes. These turn out to be very different from the well-established processes of adoption of add-on innovations, in the 'more of the same' fashion, which occur when the farmer tries to improve conventional farm management.

Learning can be facilitated (relationship 3). The facilitation of learning is also a core subject of the book. Most of the contributors, including the editors, are engaged in extension and innovation studies. That is, they are interested in fostering voluntary change in behaviour through communication, and in innovation as an outcome of social interaction (e.g. Röling, 1988). Other perspectives on innovation, for example, as a process induced by changes in relative factor prices (Ruttan and Hayami, 1984) are not dealt with, although we recognize that changed relative factor prices might well motivate innovative interaction.

The case studies reaffirm the proposition that learning and facilitation occur in specific institutional frameworks and policy contexts (relationship 4), and that the nature of these frameworks and contexts is of crucial importance for the transformation of farming. Moreover, the cases illustrate how the institutional and policy changes required for scaling-up successes achieved on a pilot scale cause strife and conflict for which appropriate communication and negotiation strategies and methodologies are needed.

natural resources in a more sustainable manner. A great deal of information is available on that issue (e.g. Howard, 1943; National Science Council, 1989; Reijntjes et al, 1992; Pretty, 1995). Jiggins and De Zeeuw (1992) provide pioneering information on Participatory Technology Development (PTD) for sustainable farming, while Pretty's (1995) authoritative book on regenerating agriculture provides a wealth of information on its feasibility and the conditions for transformation.

We do not limit ourselves to the field or farm level, but explicitly also take into consideration larger-scale agroecosystems, such as water catchments, which need to be managed in their own right in order to allow sustainable management at the field and farm levels. Since this book assumes that the transformation to sustainable farming is social as much as agronomic and ecological (Vartdall, 1995), we shall examine these agroecosystems by looking at innovation processes at levels of social aggregation concomitant with the scale of the agroecosystem.

The contributors to the book bring along a wide range of experience assembled during widely different life times, from widely different contexts, which allows examination of the transition to sustainable agriculture from widely different perspectives, at different levels and along different dimensions (Box 16.2).

Box 16.2 *Profile of the contributors*

Campbell and Wagemans are senior policy makers in government, while Woodhill plays the same role in an environmental voluntary organization. All three also undertake consultancies in other parts of the world.

Fisk, Hesterman and Thorburn work for the W.K. Kellogg Foundation (WKKF) in various capacities. WKKF is a philanthropic foundation which supports learning in and about agriculture and rural development.

Boerma, Hamilton, Roux, Van de Fliert and Van Weperen play professional roles as consultants, project leaders or implementors.

Aarts, Gerber, Koutsouris, Papadopoulos, Proost, Van de Fliert (who has two jobs) and Wagemakers work for universities as lecturers and researchers; Somers is a researcher in a research institute.

Blum, Castillo, Hoffmann, Pretty, Röling and Van Woerkum are university professors who hold (or held, Castillo is emeritus professor) chairs in departments of extension studies of one kind or another. Jiggins holds a chair in the field of human ecology. Hesterman has worked as a professor in crop and soil science. All undertake consultancies in various parts of the world.

Sustainable Agriculture

Productivity equity, sustainability and stability have been identified as key goals of agricultural policy (Conway, 1994). But they are not necessarily mutually consistent. Conway speaks of 'trade-offs' among them, especially between the economic and ecological. This book is weighted heavily towards ecological imperatives. Maintaining or enhancing the natural resource base is the precondition for a sustainably productive agriculture.

Box 16.3 outlines the main aspects we shall examine. These aspects relate systemically to one another, in that change in one aspect necessarily affects the others. For example, the learning required for effectively practising Integrated Pest Management can apparently not be achieved by the transfer-of-technology (TOT) mode of extension. It requires a new approach to facilitation (Matteson et al, 1992), which in turn has important implications for institutional support. We come back to the five dimensions in the last chapter, where we examine models of innovation which are suitable for understanding the transformation to sustainable farming.

We shall not define sustainability solely in terms of the carrying capacity or other 'hard' characteristics of an agroecosystem. We use a social science definition (Box 16.4) that, as our cases show, proves to be eminently practical. We borrowed the definition from the 'Hawkesbury pioneers', a small band of agriculturalists at the University of Western Sydney in New South Wales (Sriskandarajah et al, 1989; Bawden and Packam, 1991; Woodhill, 1993; Ison, 1994).

The definition in Box 16.4 incorporates elements which focus on the hard properties of a farm or an agroecosystem. Yet we suspect that our seemingly relativist definition will irritate those who want to use scientific definitions to identify the limits beyond which use of natural resources should not go (Korthals, 1994).

Box 16.3 *Five interlocking dimensions of the transformation to sustainable farming*

- agricultural practices, both at the farm and higher system levels;
- learning those practices;
- facilitating that learning;
- institutional frameworks that support such facilitation, comprising markets, science, extension, networks of innovation etc.;
- conducive policy frameworks, including regulations, subsidies etc.; and especially:
- the management of change from conventional to sustainable agriculture along each of the dimensions.

Box 16.4 *Sustainability defined*

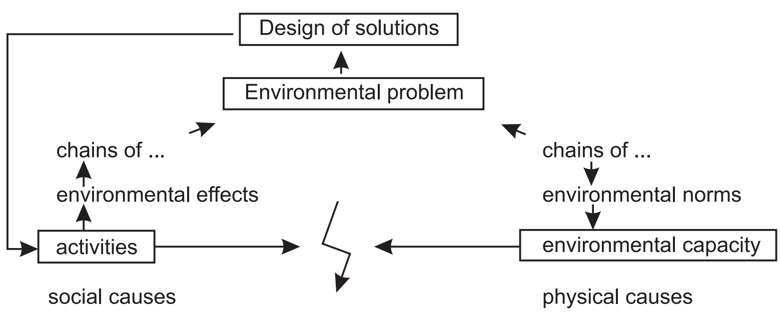
Sustainability is an emergent property of a 'soft system' (Woodhill and Röling, this volume). It is the outcome of the collective decision making that arises from interaction among stakeholders. Stakeholders are identified here as natural resource users and managers. A natural resource can be considered at the field, farm or higher level of aggregation, including watersheds, landscapes, agroecological regions, lakes and rivers and, ultimately, the Earth itself.

The formulation of sustainability in this manner implies that the definition is part of the problem that stakeholders have to resolve (Pretty, 1995). That is, securing agreement on what people shall take sustainability to mean for a given environment, is half the job of getting there.

None the less, our definition, as this book shows, has proven robust because it fits so well the outcomes of research on the interface between people and their environment. It also serves our immediate purpose of illuminating the facilitation of sustainable agriculture.

Our definition is consistent with Wouter de Groot's (1992) 'problem-in-context framework for the analysis, explanation and solution of environmental problems' (Box 16.5). A problem is here defined as an undesirable difference between 'wants' or norms, and 'gets' or impacts. According to De Groot, an environmental problem is an undesirable difference between the environmental impacts of human activity and environmental norms. Solving environmental problems thus requires changing human activity to fit the norms, and vice versa. The problem-in-context framework provides for an integration of environmental sciences and the derivation of norms for human activity.

Box 16.5 *De Groot's 'Problem in Contex Model' of environmental problems (simplified adaptation of De Groot, 1992).*



Is it Immoral to be Concerned About the Health of Natural Resources?

The term 'sustainable agriculture' implies regenerative practices which optimally use locally available resources and natural processes, such as nutrient recycling; build on biodiversity; regenerate and develop natural resources; and limit the use of external inputs of agrochemicals, minerals and non-renewable energy. Regenerative agriculture requires that, where used, such external inputs are used efficiently so that emissions can be recycled and absorbed (Pretty, 1995), renewable resources are regeared and non-renewable resource use generates optimal productivity.

Defined in this way, regenerative agriculture, in terms of yield, at present tends to be slightly less productive than high-input agriculture in industrial countries, and approximately as productive as such agriculture in 'Green Revolution' areas. On presently available evidence, state-of-the-art regenerative practices would increase significantly productivity in the rainfed, complex and resource poor areas in developing countries which have so far not benefitted from high external input technologies and are usually heavily degraded (Pretty, 1995).

The question then arises whether, from a global point of view, regenerative agriculture can deliver the output required to meet aggregate demands. The trend line extrapolation of growth in the world's population to more than 8 billion in 2025, an increase of over 2.5 billion in the next 30 years, has led many authors to emphasize the need to double productivity per hectare of available farm land (McCalla, 1994; CGIAR, 1995; Tansey and Worsely, 1995).

The productivity deemed possible under regenerative agriculture and the doubling of productivity per hectare of available land required by 2025 seem contradictory. Indeed, one expert claims that promoting a form of agriculture which uses no artificial fertilizers or chemical pesticides is immoral because it undermines global food security (quoted from Rabbinge in WUB 17, 11 May 1995).

It suffices in this introductory chapter to highlight the irreducible uncertainty about what lies ahead over the next two or three decades. On the one hand, while there is at present ample grain available in global food markets to feed the world's present population, many millions continue to go to bed hungry. This has to do with the fact that surplus production is not directly related to the relief of chronic hunger. Many of those who are hungry have neither the means to produce sufficient to feed themselves, nor the money to buy it. The issues of inequity and distribution are likely to remain present into the foreseeable future, at any level of grain production, or population growth or environmental change.

On the other hand, although present estimates of production potential indicate adequate capacity to meet the food needs in aggregate of up to twice as many people as are alive today, such estimates are by their very nature conditional, and hedged around by assumptions about what might happen in other sectors. For example, estimates of the future adequacy of water supplies to agriculture are dependent on considerations such as demands for water from industrial, recreational and domestic users, the rate at which water loss is controlled, the efficiency of water use and the rate at which water-winning and water storage technology is introduced.

Further food output scenarios also are strongly affected by assumptions made about the outcome of political negotiations concerning acceptable levels of environmental pollution, degradation and waste, questimates concerning the mobilization of political will to invest in the health of soil amelioration measures, which would open up hitherto unusable areas to cultivation, as well as price relationships, market developments and changes in consumer preferences.

In addition, the introduction of factory-based production of meat muscle (already foreshadowed in the UK Government's technology foresight programme) could relieve much of the pressure of livestock farming on grasslands, for example, while an acceleration of the already observable shift towards more vegetarian diets in Northern consumer markets (e.g. Kleiner, 1996) would markedly change food demand forecasts. The likelihood of rapid change in global temperature and rainfall patterns adds further uncertainty.

Conversely, continued reliance on high-energy input, chemical-dependent, intensive farming as the sole or even the main source of global surplus would appear to be environmentally foolhardy, and increasingly unacceptable politically as the wider consequences to human health, ecosystem and valued landscapes become apparent.

'Making the Flip'

Historically, the number of people and their 'wants' have grown, and uses of natural resources to satisfy them have been developed, regardless of the longer-term consequences for the environment (Ponting, 1991). In this book, we consider the alternative, indeed the necessity, of 'making the flip':

- conserving, even enhancing, the natural resource base upon which all agriculture ultimately, and indeed human survival, depends;
- the resultant negotiations involved in the transformation of wants to accommodate the emergent understanding of the natural resource imperative;
- the kinds of agriculture which then results from such a reversal of attitudes, approaches and behaviour.

The book illustrates the social energy which is created as people and institutions begin to engage in accommodation of 'wants' to 'effects'. The evidence suggests explicitly that the way to capture the potential for productivity, which is realizable by paying heed to the health of natural resources, is to work with and support the creativity, diversity and serendipity which emerges from a process of social learning.

In agriculture, the process requires that farmers become experts, instead of 'users', 'receivers' or 'adopters' of other specialists' wisdom and technologies. They must learn to apply general ecological principles to their own locality and time-specific situations. They must be able to manage complex agroecosystem systems as businesses in competitive markets. But, as ecosystems do not stop at farm boundaries, local communities and wider consortia of interest groups and resource users also need to engage in learning how to manage landscapes and resources. Societies have to develop, and adjust to, trade-offs among potentially competing interests. We still have a long way to go in that respect. On the whole, a wasteful way of life has so far remained politically non-negotiable.

The Prevalent Paradigm for Thinking About Innovation

The current ways of thinking about the processes of innovation are embedded in a particular *epistemology*, that is in ways or methods for knowing on the basis of knowledge which hitherto has remained largely unchallenged.

The prevalent view of agricultural science is that it deals with 'things', which are as they are, which can be objectively known through research, and about which science can formulate generalizable 'truths'. These objectively verifiable propositions underpin the efforts made to influence agricultural performance. The goals of such intervention are taken to be unambiguous and not of scientific interest. The focus is on the 'best technical means' for achieving any stated goal. Box 16.6 presents typical statements which are informed by this so-called realist–positivist epistemology.

Box 16.6 *Illustrative realist–positivist statements*

- Reality exists independently of the human observer.
- Through scientific research we can build objective, true knowledge (generalizations) about that reality.
- Scientists discover and lay bare the naked truth, lift the veil hiding it, and reveal its secrets.
- The goal of science is to add to the store of human knowledge.
- Scientific research is the source of innovation.
- Technology is applied science.
- Development results from the transfer of the results of science to users.
- Problems can be solved by experts. In fact, we do not have to worry too much about the future. Science will find an answer.
- Social science is not really a science: it has not resulted in any true generalizations and cannot be used to send a man to the moon.

The realist–positivist epistemology is a coherent and internally consistent paradigm which most agricultural professionals have drilled into them, or absorb during their training, whether it is technical or social, and whether it is at an academic, polytechnic or secondary level institute. But it is an epistemology which is increasingly incompatible with the search for a sustainable society.

Kuhn (1970) has opened our eyes to the notion of coherent and internally consistent paradigms which shift as the number of plausible knowledge claims which are in conflict with them increases. We then move from a period of 'normal science' during which people agree on the fundamental premises and occupy themselves with questions within the paradigm, into a period of 'post-normal' science, during which the paradigm itself is contested.

An increasing number of knowledge claims which are inconsistent with the realist–positivist paradigm (Box 16.7) arise in current debates about agriculture and the environment.

Box 16.7 *Some claims at odds with the realist–positivist paradigm*

- Agriculture has multiple goals which are not mutually compatible. Hence the assumption of unambiguous goals and the focus on 'best technical means' is becoming irrelevant. The need for arbitration among contested goals is becoming one of the key challenges in dealing with our natural resources.

- Decisions about the use of natural resources are less and less a question of expertise or the province of specialist institutions, and more and more determined by negotiation and agreement among stakeholders. The focus shifts from result to process. The problems we are faced with have less to do with instrumental problems, i.e. people–thing problems, and increasingly to do with people–people relationships, i.e. social problems. This has important implications for agricultural science which has so far profiled itself as a biophysical and technical activity.

- In the conventional paradigm, innovation is seen to originate in science and to be realized through the transfer and adoption of the results of science (the linear model or transfer-of-technology (TOT) model). But it is increasingly clear that, in practice, innovation emerges from interaction among various 'actors', i.e. among people and collectivities as role playing and sense making beings. Each one contributes to the final outcome (e.g. Kline and Rosenberg, 1986; Engel, 1995). Local knowledge, business ingenuity, farmer experimentation and inventiveness are as important as expert knowledge and the role of specialized actors such as scientists and farm advisors.

- Agricultural development is conventionally seen as driven by technological change. However, few would now disagree that price changes, improved institutional support (reducing transaction costs), conducive policy contexts, value shifts and social organization can be necessary conditions for, and sometimes the stimulus of, innovation.

The erosion of realist–positivism as a universally trusted epistemology appears to be associated with other important societal changes. For one, the trust in experts and specialized institutions is waning. A recent survey found, for example, that British respondents do not trust the information about biotechnology which they get from scientists, business corporations or the Department of Trade and Industry. They prefer to trust organizations such as Greenpeace (Tate, 1995).

The erosion of trust also appears to be related to uncertainty about issues for which the stakes are high, such as global food security which was touched upon in the section 'Is it Immoral to be Concerned About the Health of Natural Resources?' and 'Making the Flip'. Funtowicz and Ravetz (1990, 1994) argue that we have entered a period of 'post-normal science' in the sense of Kuhn (1970) because 'normal science' cannot deal with conditions of high uncertainty. The development of reliable grounds for knowing must proceed in part along other lines. Self-appointed activists emerge, who become formidably well informed across discipline boundaries about a subject or situation which threatens their values or livelihood. Decision fora include speech-makers and citizens, as well as scientists or specialists, and 'facts' encompass people's values and express cultural meaning. The final arbiters of reliable knowledge are 'extended peer communities' made up of a much wider membership than the conventional narrow professional elites or restricted political circles.

Funtowicz and Ravetz (1994) speak of the 'democratization of science'; that is, a widely shared process of learning and informed public debate about goals, and not just means, seems the only acceptable way to deal with high uncertainty when the stakes are high and the consequences of getting it wrong are potentially catastrophic.

This observation is reminiscent of Habermas' (1984, 1985) argument that society can overcome the momentum of what we have constructed in the past – and thus prevent the Norsemen on Greenland scenario – only by reaching consensus about what action to take next; that is, not on the basis of controlling things (instrumental rationality), nor on the basis of beating competitors or opponents (strategic rationality), but on the basis of shared learning, collaboration and the development of consensus about the action to take (communicative rationality).

Constructionism

Constructionism is the name given to the epistemology which supports the learning processes described in this book. If everyone agrees about the goals, we can afford to worry about the best technical means of securing those goals. If everyone agrees about the facts, we can speak of objective truth. 'Objective' knowledge has, therefore, by no means become outdated or unneeded. But, if these conditions do not hold, we have to stretch the positivist epistemology and embrace constructionism. Reality no longer appears as a 'given' but as something actively 'constructed'

Box 16.8 *Constructionism and quantum physics*

Niels Bohr did not believe in the Newtonian clockwork universe (which was the conventional perspective early this century). 'There is no quantum world. What exists is a quantum physical description. It would be mistaken, therefore, to believe that it is the task of physics to find out what nature is. Physics occupies itself with what we can say about nature' (quoted in NRC/Handelsblad, 18 May 1995). Another quantum physicist, David Bohm, said: 'It is not the task of science to increase the store of knowledge, but to formulate fresh perspectives' (1993). Some researchers and analysts reject constructionism because of its apparent relativism (Röling, 1995). If it is people who construct reality, there must be multiple realities. What the one has constructed can be deconstructed by someone else. Everything can be true.

by people. There are three main strands in constructionist thinking (Knorr-Cetina, 1995).

In the first place, reality is said to be socially constructed (Berger and Luckmann, 1967). It is created in the discourse of, and negotiations among, people as social actors. Socially negotiated agreements become experienced as 'objective' truth. Berger and Luckmann concern themselves with the mechanisms by which objective social order emerges from interaction.

Second, convincing empirical analysis of 'fact production' in natural science laboratories by, e.g. Knorr-Cetina herself (1981); Collins (1985, 1992) and Latour (1987) has focused attention on epistemic practices and human construction in the very area we used to think of as given natural reality (Box 16.8).

Third, biological research into the 'observing organism' (Maturana and Varela, 1987) has demonstrated that the environment external to the observer, be it a frog or a person, does not project itself objectively on to the nervous system. Perception is accomplished by the brain, and the brain is an informationally closed system that reconstructs an external environment only from environmental 'triggers', memory and interaction with itself.

We explicitly reject such an interpretation of constructionism. There is an environment. If an organism loses touch with it, or, as Maturana and Varela (1987) put it, if the structural coupling between organism and environment is broken, the organism cannot survive. But the 'constructions' appropriate for survival are not fixed or self-evident, nor is their interpretation unambiguous. They have selectively evolved, are culturally conditioned, continue to be actively created, or learned experientially on the basis of trial and error, or vicariously on the basis of communication. In this scheme of things, science has a role to play. It is engaged in the active construction of reality. But its impact is not based on the predictive power of its generalizations, however, but on the extent to which it affects other people's reality construction.

Social actor network theory (Latour, 1987; Callon and Law, 1989) takes this a bit further. It claims that the impact of scientific results is based on the extent to which the laboratory conditions, which gave rise to the results, are replicated in society. These conditions are the outcome of the efforts of people who have an interest in creating and maintaining them. That is, 'social actor networks' are necessary to maintain these conditions. Changing the conditions, for example, as a result of trying to reduce the use of chemical inputs in agriculture, invariably leads to resistance as actors' interests are affected (e.g. Aarts and Van Woerkum; Hamilton). The transformation to sustainable agriculture is not politically neutral.

What about the impact of social science? As we have seen earlier, from a positivist point of view, social science has little to contribute, but from a constructionist view, the contributions are assessed in different terms. All forms of knowledge which claim the 'science label', social science included, are seen as special cases of social reality construction. The scientist actively constructs a fresh perspective on reality and this, in turn, affects the way others see it. Giddens (1987) has called this 'the double hermeneutic'. The behaviour of celestial bodies such as the sun and the Earth presumably remain the same, whether people think the sun circles around the Earth or vice versa, but people and societies do change their behaviour in the light of what science has to say about celestial movements. This also holds for the social sciences. Economics, for example, has been quite effective during the past few decades in making us believe that we are largely driven by maximization of monetary values and that society must be organized to allow the unhindered operation of market mechanisms.

The impact of constructionist thinking becomes abundantly clear if we consider what it implies for the professional field of most of the contributors to this book: extension studies (Box 16.9) (Leeuwis, 1993). Within the realist–positivist epistemology, extension is looked upon as a necessary delivery mechanism of the results of scientific research. We do not need to repeat the criticism of that perspective here (Freire, 1972; Chambers, 1983; Kline and Rosenberg, 1986; Röling, 1988; Long and Van der Ploeg, 1989). Within the constructionist epistemology, extension is a means for socially (re-)constructing agrarian reality through communication and information sharing activities. More generously and truly constructionally, extension can be seen as a societal mechanism for facilitating social learning of appropriate responses to changing circumstance. It is easy to see from this perspective how the transformation of agriculture implies an active social reconstruction of what our natural resources mean to our survival, and how to use them to support our continuing livelihood. It is equally easy to see that the transformation cannot be accomplished only on the basis of positivist science, elite expertise and on transfer of technology to farmers.

Soft Systems Thinking

Finally, it is necessary to say by way of introduction that we accept systems thinking as a necessary holistic approach to complex issues such as the sustainability of agroecosystems. Such issues cannot be understood by examining only the parts in

Box 16.9 *Extension*

Although literally hundreds of thousands of people in the world earn their living as professional extensionists, the area of endeavour remains murky and difficult to explain. One reason is the diversity of perspectives with which extension is construed and which are often based on differences in basic assumptions about agricultural development, the role of science and so forth.

The word 'extension' originally refers to extending scientific education beyond the walls of school or university (Van den Ban and Hawkins, 1988, 1996). Often the word 'extension education' has therefore been used. This idea is close to the French concept of 'vulgarization', making accessible scientific or other elevated thoughts to the 'vulgus' or ordinary people. Consistent with this notion is the emphasis on technology transfer from scientific research to farmer users (the TOT model) as the central mandate of extension.

But, other concepts are being used which reflect an entirely different perspective. Thus farm advisory workers, or, in German, 'Beraters', have less of an educational or transfer and more of a consultant role. Words such as 'mobilizer' or 'facilitator', which try to avoid the implication of external imposition, go even further.

Extension, as a practice, is underpinned by a body of knowledge and accumulated experience which has, at one time, been called 'extension science' (Röling, 1988), but which perhaps can be better labelled as 'extension communication and innovation studies' to reflect a more constructionist perspective on science. Many of the contributors to this book are engaged in such studies (Box 16.2).

But, extension and innovation studies cannot be considered a discipline. Innovation, including the transition to sustainable agriculture, cannot be understood by focusing only on extension communication, but requires taking account of intentionality, culture, power, technology development, institutions, policies and, of course, epistemology.

isolation, nor the whole as a mere aggregation of parts. Tasks such as ecosystem management require that the emergent properties of systems as wholes are taken into account (e.g. Hurthubise, 1984). 'System performance must therefore be judged not simply in terms of how each part works separately, but in terms of how the parts fit together and relate to each other, and in terms of how the system relates to its environment and to other systems in that environment' (Dillon, 1976).

Constructionism has deeply affected the thinking about systems which emerged from biology and other 'hard' sciences and was later applied in engineering. Checkland (1981; Checkland and Scholes, 1990) distinguishes between 'hard' and 'soft' systems. The former are treated as if they really exist. Their boundaries and goals are assumed to be given. Analysis and problem solving focus on goal-seeking and the best technical means to reach a goal. Such hard system thinking can be usefully applied to natural systems, such as plants, or designed systems, such as computers.

Soft systems are deliberate social constructs, that is, they exist only to the extent that people agree on their goals, their boundaries, their membership and their usefulness. The crucial assumption is that system goals are not given but contested and that system boundaries are negotiated. The necessary condition for a soft system to exist is agreement among its members on its goals. A soft system may also be defined as a human activity system, e.g. an organization, a task force or the stakeholders in an agroecosystem who have been forced by environmental problems to exert joint agency at the level of social aggregation commensurate with the agroecosystem. Thus the agroecosystem is a subsystem of a human activity system, and its sustainability is an emergent property of that soft system. In this perspective, hard systems are subsumed by soft systems, just as scientific research is a special approach to the social construction of reality.

A special application of soft systems thinking is represented in what are called agricultural knowledge and information systems (AKIS) (Röling, 1988, Röling, 1990; Röling and Engel, 1991; Engel, 1995). AKIS can be used in a number of ways:

- empirically to discover how social actors in agriculture, such as scientists, advisers, farmers, but also seed suppliers, credit banks and so on, are linked together in the creation, adaptation, sharing, storage and application of knowledge and information;
- normatively, as a mental construct, to design ideal links and flows;
- analytically to guide interventions to ensure that the actors do, in practice, interact in ways that give rise to desired emergent properties, such as innovation. System boundaries can be drawn widely, to achieve goals such as a competitive and productive and/or indeed a sustainable agriculture, or narrowly to achieve goals such as the production of *x*-litres of milk per cow.

Peter Checkland's real achievement is the development of a soft systems methodology (SSM), which allows a group of actors who are faced with a shared problem to engage in a collective learning process in order to design a human activity system that can help solve the problem through collective action. SSM has been tested extensively over a period of more than 15 years, but especially in corporate environments. At a workshop with Checkland and some of the present contributors, it was noted that sustainability problems are more complex than corporate ones with respect to the social dilemmas which arise between individual and collective interests (Ostrom, 1990, 1991, 1992; Koelen and Röling, 1994; Maarleveld, 1996) and hence require more preliminary exploration (Leeuwis, 1993).

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17

Subsidies in Watershed Development Projects in India: Distortions and Opportunities

John M. Kerr, N. K. Sanghi and G. Sriramappa

> Development is increasingly understood to be a process whereby people learn to take charge of their own lives and solve their own problems. Helping people solve their problems by giving them things and doing things for them makes them more dependent and less willing to solve their own problems. This cannot be called development; on the contrary, it is the very opposite of development (Bunch, 1982).

Heavy subsidies are a standard component of virtually all agricultural and rural development projects in India. It is difficult to find examples of government or non-governmental projects that do not include substantial funding from the sponsoring agency. Such funding can take several forms: helping to pay for labour, agricultural inputs, machinery services or technical expertise. Sometimes assistance is provided to help rural people carry out work on their own, and sometimes the work is done for them.

This chapter discusses the effects of subsidies on watershed development projects, particularly in India, although the arguments presented are relevant throughout the world. In this chapter we do not argue against government support for agriculture and poverty alleviation. Rather, we aim to show that some unintended, negative consequences of heavy subsidies in watershed management programmes actually undermine watershed development objectives. The cause of the problem is that often watershed subsidies are intended simultaneously to support improved land management and rural employment generation. This is a lot to demand of a single policy intervention. We argue that watershed programmes could be more successful if these subsidies were reduced or eliminated, and the objectives of support for agriculture and poverty alleviation were achieved through alternative means. We conclude by suggesting alternative approaches that avoid subsidies or minimize their potentially destructive impacts.

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Government Support for Agriculture and Human Welfare

Subsidies and payments to rural people have a long history in India. Employment generation for famine relief, for example, dates back several centuries. In contemporary times, many state governments sponsor employment programmes that provide important welfare benefits. Whether for constructing irrigation canals or promoting watershed development, employment generation can easily be built into a range of rural development projects and produce tangible benefits, such as combating hunger and stabilizing rural income.

Subsidies are also often seen as a useful way to convince farmers to try something that subsequently they will adopt with their own resources. This faith in the 'demonstration effect' is common among agricultural researchers worldwide, who believe that the technologies they develop will be adopted if farmers are shown their merits. The success of the Green Revolution contributed to this sentiment in India. In the Green Revolution, scientists' discoveries on agricultural research stations led farmers literally to replace traditional farming systems, resulting in spectacular productivity increases.

Agricultural demonstrations in India take several forms. Those conducted on farmers' fields normally involve subsidies. Researchers often select a farmer who receives free inputs if he donates a field to be used as a demonstration plot. Researchers then select a technical model to test on the plot. On a larger scale, watershed programmes often supply farmers with partially or fully subsidized inputs in exchange for allowing watershed works to be implemented in their fields, or to demonstrate to farmers the complementary effects of improved inputs and cultivation practices.

Some soil and water conservation (SWC) projects in India operate in areas where agriculture imposes external costs, or externalities, in downstream locations. The classic case is when erosion on farm land leads to siltation of reservoirs or other downstream infrastructure, decreasing their lifespan at a high cost to the national economy. Several publications of the Central Soil and Water Conservation Research and Training Institute in Dehra Dun display a photograph of a bridge in the Dun Valley that was nearly engulfed by half a century of upstream erosion (CSWCRTI, 1989). Images such as this leave a powerful impression of the need for government to help pay for erosion control measures on farms, even though such externalities are not present in every case.

Subsidies were also built into early SWC programmes because of official perceptions that farmers were ignorant and would manage their land properly only under coercion or persuasion. In some cases officials designed programmes that forced farmers to comply. But farmers resisted compulsory programmes; often destroying measures introduced against their wishes after the soil conservation officials leave (Fernandez, 1993).

Today, many people view compulsory programmes as unacceptably authoritarian in nature. They seek another way to encourage farmers to adopt soil conservation practices. Paying farmers for work done on their fields offers a more socially acceptable way to try to achieve conservation objectives.

In recent years subsidies have assumed great political importance. This is partly because India, unlike many other developing countries, is a functioning democracy. The rural vote is always hotly contested in Indian elections, with politicians often resorting to vote-buying schemes such as loan forgiveness and a wide range of subsidies to attract the rural constituency.[1]

The combined result of these efforts to create employment, demonstrate technology, combat externalities, guide 'ignorant' farmers and gain political influence, is that most people in India do not question subsidies for agricultural development projects. Farmers have learned from experience that they may always expect subsidies, and the rest of society accepts – apparently without question – the idea that it should share the cost of measures intended to help farmers. There is little debate about why these subsidies are justified or what objectives they achieve. Here we argue that subsidies can hinder attempts to increase agricultural productivity and conserve natural resources.

When are Subsidies Appropriate and When are they not?

Economic policies should be used to accomplish objectives that the free market does not achieve on its own. For example, they are needed when the market sends signals to people to produce, consume or invest in ways that are economically optimal for the individual but not economically optimal for society as a whole. In the language of economics, under these circumstances the private costs and returns of an activity do not equal the social costs and returns. This situation is referred to as a market failure (Box 17.1). A policy intervention such as a tax, subsidy or a change in the laws that govern the market, can correct the market failure by realigning private and social returns of the economic activity in question. Direct government intervention can also be used to provide goods and services that the market does not provide.

Policy makers have many possible economic tools for correcting market failures. These include granting subsidies, levying taxes, assigning and specifying property rights, improving credit and insurance markets and many others. The important point is that subsidies are just one of many policy tools. Depending on the market failure at hand, a subsidy may or may not be the most appropriate policy tool.

In economic terms, introducing a subsidy is justified if two broad conditions apply:

- There must be a market failure (see Box 17.1).
- A subsidy must be the best way to correct the market failure, i.e. the one that solves the problem as directly and inexpensively as possible, with minimal side effects.

Box 17.1 *Types of market failure*

Examples of market failure, when market prices signal people to carry out activities that are not in society's economic interests, abound in natural resource management and have a variety of causes.

Gadgil (1992) describes how forest product firms with short-term concessionary rights to forest land over-harvested forests because they had no stake in their future productivity. Similarly, farmers collectively over-exploit groundwater in semi-arid regions because there are no property rights governing access to groundwater, and because electricity price subsidies encourage overuse (Kerr et al, 1997).

Village irrigation tanks are poorly managed because traditional institutions for collective action have deteriorated. Pender (1993) found that many poor farmers wished to invest in wells but could not do so due to credit constraints. Farmers in dryland conditions apply less than optimal amounts of fertilizer because of the risk that their investment will be wasted if rainfall is insufficient. In all of these cases of market failure – externalities, short time horizons, unspecified property rights, credit constraints, risk, and others – the market fails to encourage the best pattern of natural resource management, and some policy intervention is needed to make the market work better.

A policy tool that is not directly targeted to the cause of a problem might fail to solve it, or even worsen it (Box 17.2).

A subsidy should address the causes of problems, not their symptoms. A subsidy is an appropriate tool, for example, if the problem is that farmers do not invest in watershed development because the benefits go to the national economy but not to the investing farmer. In this case a subsidy can raise private returns to match social returns. On the other hand, if the problem is that a farmer cannot invest in planting trees or digging a well because he lacks access to credit, the policy should be to provide credit. A subsidy might encourage the investment in trees or wells, but it is wasteful because a less expensive policy could have achieved the same objective.

Box 17.2 *The consequences of poorly targeted policy*

In India and several other countries, policy makers alarmed by the loss of tree cover introduced laws against cutting and marketing trees, on both public and private land. On private land this legislation had a serious side effect: farmers planted fewer trees because they feared that they would not be able to sell them (Chambers et al, 1989a; Murray, 1994). The policy that was chosen was not direct enough in addressing the problem of deforestation on public land. It also had the side effect of discouraging farmers from increasing tree cover on private land. A better policy would have helped farmers plant trees and market tree products while controlling the problem of logging in public forests.

In other words, in some cases subsidies are the best policy tool, but in other cases they are not. And they have four major drawbacks:

1 They cannot be extended to everyone, because funds are limited.
2 They are wasteful in cases where another policy could be used to accomplish the desired objectives.
3 They may be difficult to remove once put in place.
4 They may cause unwanted side effects.

How Subsidies Affect Incentives

As stated above, a subsidy is a payment or service that raises the net private returns from an activity; an incentive is something that motivates or stimulates a person to act.[2] Financial subsidies are intended to increase financial incentives, but other types of incentives can be social, moral, psychological or political. There are different types of subsidies and these have different effects on a range of incentives or motivations.

Financial subsidies

Most people think of finance when they think of subsidies. The intention of a financial subsidy is to raise the incentive for people to pursue the subsidized activity. Subsidizing production of oilseeds encourages farmers to plant more of them, and subsidizing construction of contour bunds encourages farmers to build them. The economics of subsidies appears to be very simple: by making the subsidized item less expensive or more remunerative, more people will be willing to pay for more of it.

Paradoxically, financial subsidies can reduce financial incentives for people to invest their resources in subsidized activities. If a soil conservation programme subsidizes construction of conservation ditches in one village, for example, then farmers in a neighbouring village who are considering investing in conservation ditches have an incentive to postpone the investment in the hope that the programme will soon operate in their village as well. The farmer whose conservation ditch was subsidized this year has an incentive to postpone repairing or rebuilding it in the hope that a future conservation programme will pay for it. Numerous SWC programmes throughout the world have faced this experience.

Subsidies also discriminate against products and practices that are not subsidized. If a subsidy reduces the cost of a commodity or technology or a certain way of doing things, it creates a disincentive to use substitute products or technologies. Electricity subsidies, for example, can reduce the incentive to search for alternatives such as solar-powered pumps. Over time, this can impede scientific progress and stifle indigenous knowledge because it reduces payoffs for innovating and finding less expensive, more efficient ways to do things. In the case of watershed management, subsidies for certain conservation techniques reduce incentives to try other, less expensive ones.

Financial subsidies also create opportunities for corruption because they put officials and influential beneficiaries in a position to mismanage funds and other programme benefits. In a worldwide review of food-for-work programmes, corruption occurred more often than not (Jackson, 1982).

Psychological and moral disincentives

Financial subsidies risk causing even more damage to psychological, social or moral incentives than to financial incentives. The experiences of innumerable agricultural development projects around the world demonstrate the psychological effects of cash and kind subsidies. Too often, villagers who receive free machines, irrigation wells or other items do not maintain or manage them properly. They value the services of free items, but they do not treat them as they would treat something they paid for themselves. These free items, or giveaways, never seem to last as long as comparable items purchased by farmers with their own money. If the machine breaks, they look to the agency that provided it to repair or replace it.

Rural development agencies everywhere are now finding it difficult to operate without subsidies because villagers accustomed to giveaways act as though they are morally entitled to handouts, but not morally responsible for trying to solve their own problems. In this sense financial subsidies create *disincentives* that retard development.

Subsidized services

Development projects that provide services rather than funds offer another form of subsidy. Some subsidized services play an important role in the economic development and well-being of any country, and their potential benefits should not be discounted. Education is the best example. In rural development efforts, assistance that enables people to do things they could not (or believe they could not) do, can have a powerful, beneficial effect.

Not surprisingly, however, subsidized services that are not carefully designed can have the same negative effects on incentives as financial subsidies. For example, if a project relies on outside technical experts to perform such activities as maintaining accounts, managing marketing efforts, or organizing and mobilizing people to perform some work that benefits the community, these activities are likely to cease once the project has ended. Instead of working for themselves, villagers wait for outsiders to do things for them as they have become accustomed to relying on someone else to do the work, and hence have not developed the necessary skills. In the extreme case, external agencies even discourage villagers from thinking for themselves, suggesting solutions to villagers' problems and offering to subsidize them. This leads villagers to say, 'Tell us what we need', instead of, 'We need this. What do we need to do to achieve it?' (Barbara Adolph, ICRISAT, personal communication).

The key principle here, then, is that subsidized technical assistance should be targeted as much as possible towards helping people do things for themselves as opposed to doing things for them. This is an obvious and often-quoted principle, but it is easy to forget. Sometimes the line between the two is fine, and to avoid crossing it requires great effort. This is because it is usually easier to do something for people than to teach them to do it themselves.

How Subsidies can Undermine Watershed Management Projects

Many Indian government SWC programmes operate through heavily subsidized SWC packages. In these programmes, farmers have little say in the choice of technologies to be used on their fields, but they receive benefits ranging from several days of employment to free fertilizer, seeds and other inputs. The people responsible for implementing the work have little or no say in the project design, and they are evaluated by government auditors on the basis of the level of expenditure and the area covered by the physical structures they construct (government watershed officials, personal communication).[3]

This approach and its results are very similar to those of the compulsory programmes of old. Many farmers adopt the technology not because they like it, but to obtain free inputs or employment. Sometimes the implementing agency, under pressure to achieve quantitative targets, convinces any resisting farmers to accept the work by increasing the subsidy payment (government watershed official, personal communication). In this way all parties are satisfied: farmers receive substantial benefits and officials achieve their quotas. The drawback is that farmers' fields are littered with mechanical structures or vegetative barriers that they do not necessarily want. The structures are removed or left to deteriorate once the project staff depart.

Subsidized technology

Scientists and project managers who are confident in the technologies they develop often design top-down projects with minimal input from farmers. But even if a technology is scientifically sound, it may not suit the needs of farmers, who often have multiple objectives and constraints that cause their preferences to differ from those of scientists (Kerr and Sanghi, 1992; Chambers et al, 1989b; Pimbert, 1991).[4] But if subsidies are high enough – often in India they reach 75 per cent, 90 per cent, or even 100 per cent – then farmers might accept them for reasons unrelated to the characteristics of the technology.

Experience shows that farmers are very particular when it comes to accepting new agricultural technology, particularly in unproductive, risky dryland environments.

Box 17.3 *Subsidized technology in Indian soil and water conservation*

Many soil and water conservation programmes in India subsidize certain pre-approved technologies such as earthen bunds or vegetative barriers. These subsidies make farmers more likely to accept subsidized techniques and less likely to search for less expensive alternative conservation measures. In this way, subsidies inhibit farmers' creativity and slow the development of indigenous knowledge.

An extreme example of this problem is found in hilly, rocky parts of India where the soil is very shallow. One watershed programme operating in such an area subsidized the use of vegetative bunds but not stone bunds; another programme in a similar agro-climatic region subsidized earthen bunds but not stone bunds. In the former case the vegetative barriers could not grow because the stony soil prevented the roots from penetrating. In the latter case, the soil was so shallow that removing it to build earthen bunds would have seriously damaged agricultural productivity.

In both of these areas there was a rich tradition of farmers' own investments in indigenous SWC measures, particularly stone bunds and enclosure walls. In the former area, the project subsidized labour for planting cactus hedges so heavily that it became a highly profitable activity. Farmers responded by planting cactuses next to their existing stone walls. The cactuses served as no more than decoration, but they met the farmers' primary objective of earning subsidy payments.

Achieving progress in agricultural development in these areas means understanding the subtle factors that contribute to farmers' decisions. Scientists and project managers should encourage farmers to test new technologies and consider how to adapt them to suit their needs. Clearly, the complicated task of sorting out the many determinants of farmers' acceptance of new technologies becomes even more difficult when large subsidies tilt the balance in favour of adoption (Box 17.3). Of course, the decision to adopt under these circumstances is likely to be reversed once subsidies are removed, and farmers' suspicions that scientists and programme managers do not understand their needs will be reinforced.

The problem becomes more damaging once farmers become accustomed to heavily subsidized projects that deliver unsuitable technology. In this case farmers anticipate the benefits of subsidies but do not expect anything else of value. In India, many farmers do not take government projects seriously, and they are upset if they do not receive giveaways (Sanghi, 1987). Under these circumstances, heavily subsidized projects are doomed before they begin. Moreover, new projects that attempt to operate without financial subsidies are not welcome: farmers evaluate them in advance on the basis of what giveaways they offer rather than on their merits (Bunch, 1982; Valdes, 1994).

Subsidized inputs

In some watershed projects and on-farm research demonstrations, farmers who adopt SWC practices receive free inputs, such as seeds and fertilizer. The idea behind these giveaways is to demonstrate that improved inputs in combination with SWC measures will result in high yields. Some farmers, however, accept the inputs but then sell them or use them on their irrigated plots rather than on dryland watershed plots (Y. Mohan Rao, ICRISAT, personal communication). As a result, the project fails to achieve the desired demonstration effect, and project officials and scientists obtain no information about farmers' reactions to the technology that might suggest ways to make it more acceptable to them.

Subsidized labour

Some projects subsidize labour devoted to watershed works. In both government and NGO projects, 90 per cent or 100 per cent labour subsidies are common. In fact these subsidies exceed 100 per cent, because they use the legal minimum daily wage of Rs. 22, whereas the market wage in the dry season falls to below Rs. 20 in many rural areas. Therefore 90 per cent of the legal minimum wage actually can be more than the market wage. Not surprisingly, many people eagerly participate in these programmes regardless of what they think of the technology. Formal and informal surveys (Box 17.4) of farmers in various watersheds find that they perceive employment to be the most important project benefit (ICRISAT data, 1994, unpublished).

Subsidies and replicability

Development agencies often list replicability in non-project areas among the objectives of their work. Official documents for large Indian watershed development projects, for example, cite replicability as an important objective (World Bank, 1990; Government of India, 1991). The same documents go on to explain that the projects cover 50 per cent to 100 per cent of the cost of the technologies that they introduce, with farmers contributing whatever is left. These documents contain little or no discussion of the relationship between subsidies and replicability. They

Box 17.4 *Do rural people want conservation measures or employment?*

A group of researchers carried out an informal survey of soil conservation practices in a village in Maharashtra. One of the researchers was from the government and the rest were from elsewhere. When the villagers met the government researcher, they uniformly praised the large government soil conservation programme undertaken 15 years earlier and expressed satisfaction with the contour bunds that it introduced. On the second day of the survey the government official was not present, and the villagers admitted that they did not like the contour bunds but would happily accept them as a means of gaining lean season employment. Once again, subsidies obstructed officials and researchers from gaining information that could help them to improve technologies and project design.

Source: Personal communication with farmers justify subsidies as supporting the demonstration effect, but there is no serious discussion of how subsidies will be phased out. For true replicability, however, phasing out subsidies is critical because funds are not available to provide them except in a limited area and for a limited period.

Because subsidies cannot be made available to everyone – certainly not to all of India's hundreds of millions of farmers – it is probably better not to introduce them in the first place. A watershed project initiated without subsidies obviously faces a more accurate test of replicability than any project supported by subsidies.

Paying for participation

Participatory watershed projects are intended to overcome the problems faced by top-down projects. Participatory planning between farmers and watershed officials is expected to ensure that the technologies selected are both technically sound and acceptable to farmers. Experience shows that this approach is very sound, but if it includes high subsidies, especially subsidies for labour, participation actually can worsen the problem of encouraging farmers to accept useless technology. Two examples illustrate this point (Box 17.5).

These two examples are probably replicated on a daily basis in heavily subsidized, participatory projects in India. The essence of the problem is that subsidies distort incentives so that farmers select the technology made most attractive by the giveaway rather than the one they think is best on its own merits. Project officials too trusting of farmers' wisdom are likely to be fooled in such cases.

Box 17.5 *The consequences of subsidized participation*

A programme in Andhra Pradesh aimed to encourage farmers to build bunds on their land. The project paid the farmers to carry out the work on their own land and allowed them to choose their own technology. Two soil scientists visiting the project in 1993 noticed that on some fields earthen bunds were far larger than necessary, and that they actually did more harm than good by taking scarce topsoil from the field. They also noticed that a large stone structure on the boundary of one field served no apparent purpose. Further investigation suggested that the lure of guaranteed employment led the farmers to build large bunds regardless of their purpose.

The second case concerns a participatory watershed planning exercise held in a drought-prone area of Andhra Pradesh. Under the project, villagers were to be hired to carry out work jointly planned by villagers and project officials. When the villagers were asked to present their plan, they said that enlarging the massive irrigation tank bund was their top priority, even though the tank had filled only three times in the previous ten years. Subsequent investigation revealed that the farmers did not really think that the bund needed to be raised, but they knew that such a large project would employ them throughout the dry season, relieving them from having to migrate to Hyderabad or Madras.

True participation means working together towards a common objective. This will not be possible if the very design of projects creates incentives to mislead and deceive. Subsidies can create such incentives.

Promoting Watershed Development Without an Over-reliance on Subsidies

If subsidies, particularly high subsidies that create employment or target specific inputs or technologies, can create so many problems in watershed development projects, what should be done? First, subsidies should be avoided where there is no obvious justification. Second, where subsidies are justified they should be designed and implemented in such a way as to minimize distortions to incentives.

Designing subsidies with minimal distortions to incentives

In India, high subsidies in watershed programmes are a fact of life, and it will be difficult to remove or greatly reduce them immediately. This is partly because of a 'culture' of high subsidies where no one questions their usefulness, but also because high subsidies are written into national legislation that will not be changed overnight. This means that it is very important to devise ways to reduce the harmful impact of subsidies on watershed programmes.

One way to reduce the harmful effect of subsidies is to require matching labour contributions by landowners on whose land conservation structures are built. The idea is as follows. Farmers may choose their own conservation technology and must build half of a given structure with their own labour (either family or hired). They may then request the conservation programme to construct the second half, according to the design specified by the farmer. The conservation programme would hire the workers under the programme to do so; these workers would be paid only after the farmer certifies that the work is acceptable to him. This approach has several advantages. First, it helps ensure that the technology suits the farmer's wishes and is built according to standards that satisfy him. Second, the farmer never receives any payment, reducing the chances that he will participate in the programme for unexpected reasons.

This approach also offers the important side benefits of helping to organize landless workers and teaching them skills that will increase their self-sufficiency. In particular, labourers may form an association to provide conservation construction services. Payments from the watershed project would be made directly to the association and distributed to its members. Assistance could be provided to the association to develop their business skills and perhaps develop spin-off activities such as revolving credit programmes. More generally, this idea follows the principle of using rural development programmes as leverage to create benefits for disadvantaged groups such as the poor, lower castes and women.

Contributing an input or a technology to a group of families instead of to an individual family is an important step in this direction, particularly if one family's receipt of benefits depends on other families' adherence to agreements made under the programme. This is a well-known principle that contributes to the success of Bangladesh's Grameen Bank, where loans are made to groups of five people, and if one of them does not repay, all five lose access to further credit. Another variation on this principle is known in India as rotational credit, in which loans are provided in sequence to different people in a group. Under this system, the second loan is made only after the first is repaid and so on. Such schemes could be devised under subsidized watershed programmes in India.

However, it is preferable to avoid subsidies entirely where they are not justified economically, rather than try to cope with strategic behaviour by those who receive subsidies. The rest of this section suggests ways to promote watershed development with no subsidies at all.

Institutional innovation to manage local externalities

As stated above, subsidies for watershed management are justified when its private and social returns diverge. Recent evidence from numerous tropical countries, however, suggests that in most cases the benefits of soil and water conservation practices accrue mainly to the farmer who adopts them. The externalities that do exist are usually highly localized: soil erosion in most places does not deposit silt in downstream hydroelectric dams, but rather in neighbouring farms or ponds within the same microwatershed. Similarly, the low application rates of pesticides and fertilizer mean that run-off of poisonous chemicals is not a major problem. If there are no externalities then there is no argument in favour of subsidies; if externalities are small then only small subsidies are justified. In this case, if anyone should pay upstream farmers to adopt soil conservation it is their downstream neighbours, not taxpayers at large.

The idea of 'payments' by one group of farmers to another is not as revolutionary as it first sounds. In fact, it is an old and well-known idea among economists (Coase, 1960). 'Payment' need not mean cash or even kind transactions, but rather some kind of formal or informal compensation mechanism from one group to another (Box 17.6). Such arrangements are sometimes found in common property resource management systems, whereby a group that benefits from a collective management arrangement secures cooperation from a group that does not.

If watershed externalities tend to be small and localized, two principles emerge. First, watershed managers should begin by assuming that there is no need for financial subsidies. If subsidies are justified they may be offered, but justification should not be assumed. Second, external assistance should focus on helping people organize themselves to solve their own problems, and to facilitate access to credit, secure tenure and other factors needed to guide private incentives toward socially productive activities.

Box 17.6 *Spreading the benefits of natural resource management*

A classic example from India is the famous Sukhomajri watershed project, in which landless families received rights to irrigation water in exchange for protecting the irrigation tank catchment area. These families could then sell their water share or use it on leased land (Patel-Weynand, 1997). More recently, the National Tree Growers' Co-operative has adopted a similar approach, giving all households a share in the returns to protecting trees in common forests. Another example from India concerns current efforts in Andhra Pradesh to convert irrigation tanks to percolation tanks (Gangi Reddy et al, 1994). Under certain circumstances there can be substantial benefits from tank conversion, but they are not evenly distributed, so possibly some people who stand to lose have an incentive to sabotage the effort. Success in tank conversion projects therefore requires organizing all the people affected by the tank to ensure that the benefits are distributed in a way that satisfies all of them. No external finance is needed.

Supporting community organizations

Informal village groups can potentially serve as a focal point for efforts to resolve local disputes and mobilize farmers into action. Experience in India suggests that participation in local groups can build villagers' confidence to work collectively, to establish thrift funds to generate capital, to consider new investment opportunities, and generally to become more active (James Mascarenhas, OUTREACH, personal communication; Parthasarathy, 1994). Active local groups can stimulate psychological incentives that previously were stifled by cultural or political constraints. These potential strengths of local groups have nothing to do with external finance. In fact, they present an alternative, more sustainable way to improve the welfare of rural people.

Farmer-to-farmer extension is an offshoot of community organization. Once villagers organize, skilled farmers can serve as extension agents to spread information to their neighbours. They may have more credibility than traditional extension workers because they face the same circumstances as the people they serve. Farmer-to-farmer extension has had favourable results in many countries.

Two principles from these experiences are worth highlighting. First, every community is different, so there can be no single blueprint for designing community organizations. Second, external funds donated to community organizations should be forthcoming only to groups that have already established themselves and demonstrated that they are serious. The funds should be small and should support the costs of organizing, gathering information and spreading awareness; they should not finance giveaways.

Conclusions

In summary, there are good reasons to believe that subsidies are undermining Indian watershed development efforts. This is especially so where subsidies are very high and are tied to employment or to specific technologies that require subsequent maintenance to be useful. In many watershed programmes, subsidies lead farmers to adopt SWC techniques with no intention of maintaining them, and they make it difficult for researchers and project managers to learn what practices farmers accept or do not accept.

Many people in India believe that watershed development should he subsidized simply because so many Indian farmers are very poor and need assistance. However, projects in many countries with similarly poor farmers have removed or substantially reduced subsidies, with favourable results. These countries include Kenya, Lesotho, Niger, Haiti, Cape Verde, the Dominican Republic and the Philippines, to name a few (Lutz et al, 1994; IFAD, 1992; Critchley, 1991; Fujisaka, 1989). In some cases they found that removing subsidies made no difference; in others they found that it improved efforts to encourage conservation. Programmes under SPEECH in Tamil Nadu, Oxfam in Andhra Pradesh, and others have shown that this approach can work in India as well.

Evidence from around the world suggests that farmers will invest in conservation practices when it is profitable for them to do so (Lutz et al, 1994; Tiffen et al, 1994). This suggests that farmers do not need subsidies so much as they need less expensive, more profitable technologies; policies that encourage them to take a long-term perspective in caring for their land, greater awareness of the costs of degradation, and encouragement to organize themselves to invest in conservation (Pretty, 1995).

Even if these enabling conditions are created, there will remain poor people who need assistance to improve their livelihoods. But poor people can be helped in other ways that waste less money and do not distort incentives to invest in conserving natural resources. There is no need to tie poverty relief measures to natural resource conservation efforts.

Likewise, there are alternative ways for the government to support rain-fed agriculture. Gulati (1990) found that Indian agriculture is subject to net taxation even though many inputs are heavily subsidized. This is because price and trade policies reduce output prices and inhibit demand by more than enough to overcome the benefits to farmers of input subsidies. One obvious way to promote investment in more productive agriculture, therefore, is to alter price policies to raise farmers' profits.

Reducing subsidies substantially will be difficult in India. Farmers are accustomed to high subsidies and will oppose efforts to remove them. Also, projects that try to reduce subsidies unilaterally will face difficulties if nearby projects continue to offer large giveaways. For these reasons, removing or substantially reducing subsidies will be very challenging. A concerted effort is needed to eliminate the giveaway mentality if conservation efforts are to have long-lasting and widespread success.

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Notes

1. This situation is similar to that in Europe, North America and Japan, where subsidies are politically important and often cause major distortions to the economy. In non-democratic societies, subsidies are politically important where leaders fear being forcibly removed from office rather than voted out.
2. Sometimes subsidy and incentive are used synonymously, but not here.
3. Most of the watershed projects referred to in this paper are deliberately left unnamed.
4. Kerr and Sanghi (1992) explain in detail how differences in Indian farmers' and scientists' priorities cause them to prefer very different approaches to soil and water conservation.

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18

Agri-environmental Stewardship Schemes and 'Multifunctionality'

Thomas L. Dobbs and Jules N. Pretty

Agricultural policy makers on both sides of the Atlantic face new choices about farming and the environment. Member states of the European Union (EU) are shaping policies to implement the Agenda 2000 reforms of the Common Agricultural Policy (CAP), and these reforms are strongly influenced by the concept of multifunctionality. The Rural Development Regulation, designed as a second pillar of the CAP, allows EU member states to shift up to 20 per cent of their CAP funds to rural development and agri-environmental programmes. This could bring a major expansion of environmental stewardship programmes in Europe as EU members redirect funds from commodity support to environmental and rural development objectives. The United Kingdom, for example, shifted 2.5 per cent of all direct payments to farmers under CAP commodity regimes to rural development and agri-environment initiatives in 2001, and plans call for the proportion to rise gradually to 4.5 per cent in 2005 and 2006 (Ministry of Agriculture, Fisheries and Food; Policy Commission on the Future of Farming and Food). The United Kingdom's Policy Commission on the Future of Farming and Food recently recommended an increase to 10 per cent starting in 2004, and that serious consideration be given to increasing the proportion to the maximum 20 per cent 'if substantial CAP reform is not delivered in 2006–07' (Policy Commission on the Future of Farming and Food, p77).[1] Although the US government enacted new federal 'farm' legislation for the years 2002–2007, which greatly expands programmes and funding for conservation (USDA, 2002), debates about agricultural and related environmental policies also continue in the United States.

We draw on our recent review of agri-environmental programmes in the United Kingdom (Dobbs and Pretty) to examine key issues associated with a major expansion of stewardship payment programmes on both sides of the Atlantic. We describe the evolution of agricultural and agri-environmental policies in the United Kingdom and the concept of multifunctionality now driving European dialogue

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on the next generation of agricultural and environmental policies. Drawing on the United Kingdom experience, we also examine three key issues associated with possible major expansions of stewardship payment programmes: (1) the compatibility of *production support* and *stewardship support*; (2) balancing stewardship payments and *environmental compliance*; and (3) the compatibility of World Trade Organization (WTO) rules with stewardship schemes.[2] We conclude with a discussion of implications of the UK experience for US agri-environmental policies.

Evolution of Agricultural and Agri-Environmental Policies in the United Kingdom

The roots of current agricultural policy in the United Kingdom go back to the 1930s. Like the United States, agriculture in the United Kingdom entered a depressed condition following the collapse of farm prices after World War I, and it remained so as the industrial world sunk into depression in the 1930s. Price supports for many agricultural products had been put in place by 1932. As the likelihood of United Kingdom involvement in the European conflict grew in the late 1930s, it was apparent that the United Kingdom could be blockaded and food supplies threatened. Consequently, there was a massive effort to intensify agricultural production. Plans, incentives and mandates were put in place for farmers to convert pastures to crop production. Although price controls were in effect during the war, support prices were raised to help provide the money needed to intensify production. Farmers who failed sufficiently to comply with the intensification plans mandated for their farms could be, and sometimes were, evicted. The various policies and initiatives began a major transformation of agriculture in the United Kingdom (Potter; Wormell).

The United Kingdom determined that agriculture would not be allowed to collapse again, as it had after World War I. The principal objectives of the 1947 Agriculture Act were to increase food production and combat the chronic balance of payments deficit. In this and subsequent Acts, the United Kingdom government recommitted itself to an intensified and modern agriculture. Policy instruments included plowing grants, price subsidies for crop and livestock products, grants for field drainage and hedgerow removal and subsidies for fertilizers (Pretty, 1998). Similar policies were put in place elsewhere in Europe, and the policies began to take on greater uniformity with initiation of the CAP by the then Common Market in 1958. Much of the United Kingdom's domestic agricultural support was conditioned by the CAP following entrance into the European Community in 1973. Like US agricultural support policies, the CAP was effective in stimulating food and fibre production. However, this abundance came at increasingly high budgetary and environmental cost.

In recognition of the mounting problems with modern, intensive agriculture, policy reforms started in Europe in the mid-1980s. The Environmentally Sensitive Areas scheme was the first agri-environmental programme in the EU, launched in the United Kingdom in 1986. The next major UK agri-environmental programme was the Countryside Stewardship Scheme, established in 1991. The 1992 Mac-Sharry CAP reforms began to weaken the links between production and farm income support, and were followed with financial assistance packages to UK farmers to convert to organic agriculture or accomplish a variety of environmental outcomes.

Multifunctionality

Building on the experiences of the 1980s and 1990s, EU member states are now shaping a new generation of agri-environmental policies based upon the concept of multifunctionality (Organisation for Economic Co-operation and Development). Agriculture is inherently multifunctional – it does more than just produce food, fibre, oil and timber (Food and Agriculture Organization, Whitby). It has many functions or purposes, thereby potentially producing a wide range of outputs or services.

Agriculture that depletes organic matter or erodes soil while producing food externalizes costs that others in society must bear; but one that sequesters carbon in soils through organic matter accumulation contributes to both the global good by mediating climate change and the private good by enhancing soil health (Pretty et al, 2000, 2002). Similarly, a diverse agricultural system that protects and enhances on-farm wildlife for pest and disease control contributes to wider stocks of biodiversity, while simplified modernized systems that eliminate wildlife do not (Costanza et al, Doran and Werner, Pretty et al, 2001, Pretty, 2002).

Multifunctionality suggests agriculture can deliver valued nonfood functions that cannot be produced by other economic sectors. Much of the apparently 'natural' biodiversity in Europe is the result of centuries of farming, and agriculture has created and shaped the landscape and countryside. There are many other positive side effects of agriculture, including values derived from aesthetic appreciation; recreation and amenities; water accumulation and supply; nutrient recycling and fixation; wildlife, including agriculturally beneficial organisms; and storm protection and flood control. The idea that agriculture provides these other types of goods and services is not new, of course, and, in itself, is not controversial. The controversies surround how this concept is translated into policies.

Several major challenges face policy makers in restructuring agricultural support based on the multifunctionality perspective. With multifunctionality centre-stage in EU agricultural policy discussions, support to farmers increasingly will be tied to stewardship and other social objectives, rather than to food and fibre production. Admittedly, agricultural policies have frequently served several public policy objectives. Figure 18.1 illustrates how different agricultural policies rest along intersecting continuums. Some policies serve primarily to support food and fibre production objectives, some support primarily stewardship (environmental) objectives and others support particular social objectives. In addition, some may support a combination of two or all three of these objectives. The challenge to multifunctionalists that we focus on in this article is how to make the transition from production (top of the triangle in Figure 18.1) to stewardship policies (lower right-hand corner).

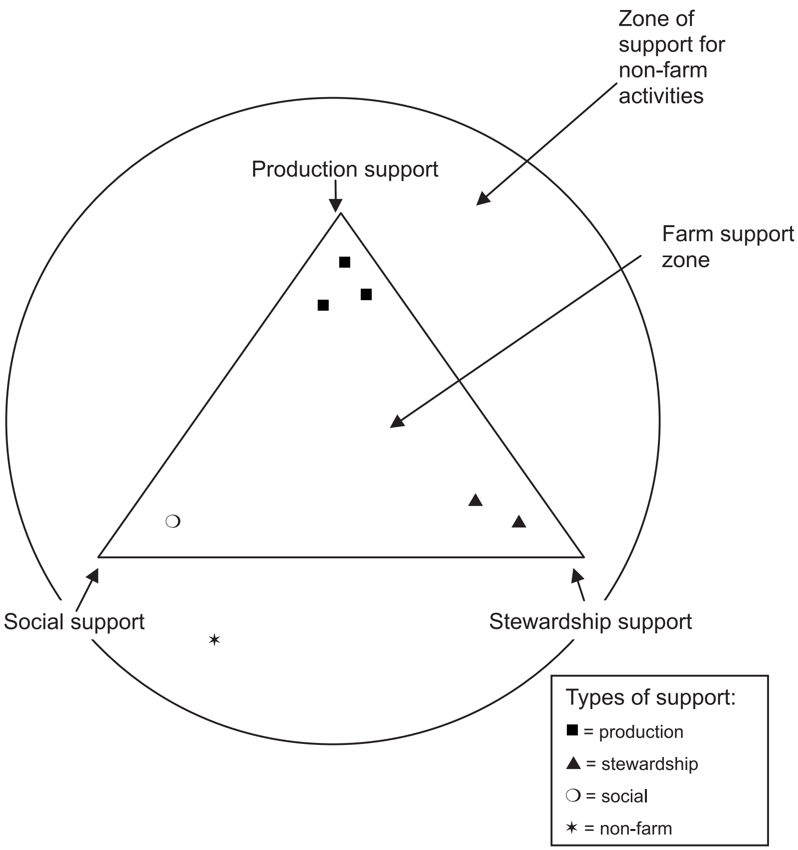

Figure 18.1 *Location of agricultural/rural support according to production, stewardship and social objectives*

In addressing this challenge, consider exactly what kinds of policies tend to be clustered in the different corners of Figure 18.1. Major examples are listed in Table 18.1. Various kinds of grain and oilseed price supports used in the EU and the United States during the last half of the 20th century clearly served primarily to increase food and fibre production. In the United Kingdom, a number of those policies initially were intended to increase production of food commodities, but they also had the social objective of supporting farm incomes. In the United States, price support policies initiated in the 1930s were intended primarily to achieve social objectives of maintaining farm income and a family farm structure of agriculture. However, because the support mechanisms were so closely tied to crop production, these policies are represented by small boxes close to the production support corner of Figure 18.1. In other words, de facto, the policies tended to support an objective that increasingly was not a priority in industrialized societies in the late 20th century.

Livestock headage payments in the EU also have been explicitly tied to levels of production. The US deficiency payment policy of the 1980s and early 1990s,

Table 18.1 *Typology of public policies/schemes according to objective with which they are most closely associated*

Production support	*Stewardship support*	*Social support*	*Support for non-farm activities*
Price supports	Organic Farming Scheme[a]	Fully decoupled income support payments	Support for rural infrastructure
Livestock headage payments	Tir Gofal[a]	Beginning 'small-farmer' loans	
Deficiency payments	Arable Stewardship Scheme[a]	'Capping' price or income support by farm size or income	Education in rural areas
Crop insurance	Norfolk Area Land Management Initiative[a]	Support for farmers' markets	Rural health care
Income insurance	Countryside Stewardship Scheme[a]		
	Environmentally Sensitive Areas Scheme[a]		
Area payments	Countryside Premium Scheme[a]		
	Integrated farming schemes[a]		
	Nitrate Sensitive Area Scheme[a]		
	Conservation Compliance		

Note: [a] UK schemes.

based on the differences between target and market prices of various commodities, had the social objective of supporting farmers' incomes but was still closely tied to production. Therefore, we consider that policy also to have been more closely tied to the partially outmoded production objective than to the actually intended social objective of increasing farmers' incomes. US crop insurance schemes in the 1980s and 1990s, and income insurance schemes piloted in the late 1990s, represent some movement along the continuum from production support toward social support. However, unless very carefully designed, they risk being tied primarily to levels of production of particular commodities. The EU's area payments, under the Arable Area Payments Scheme, are less tied to production than have been its price support policies. However, they still tend to be closer to the production end of the triangle in Figure 18.1 than to social or stewardship support.

We have examined a range of UK policies of the 1980s and 1990s that are closer to the stewardship support corner of the triangle (Figure 18.1 and Table 18.1). The Organic Farming Scheme and its predecessor, the Organic Aid Scheme, were clearly tied to particular stewardship farming systems, as were other schemes in the United Kingdom, including Tir Gofal in Wales. As we read down the stewardship support column in Table 18.1, some policies listed also have social or production elements. Conservation compliance, as incorporated in farm policy in the United States since the mid-1980s, is designed to support stewardship objectives. Commodity program benefits are conditioned on environmental performance on highly erodible cropland (Heimlich and Claassen). Most farmers have come into compliance by altering particular production practices, rather than by substantially altering their farming systems.[3] Therefore, we might think of the conservation compliance policy as being somewhere on the continuum between production and stewardship (Figure 18.1).

Transatlantic policy dialogue about multifunctionality is hindered by the often-differing European and North American values with respect to agricultural landscape and habitat.[4] Europeans value the managed landscape that has evolved over the centuries, whereas many North Americans place high value on 'wild', non-agricultural settings. There are also differences in the values put on the types of animal and plant biodiversity. Birds for hunting are highly valued in the United States, for example, whereas a wide variety of farmland bird species are valued for viewing in the United Kingdom. The basic concept of multifunctionality is the same on both sides of the Atlantic, although it manifests itself differently. Appreciation of 'traditional' farm and ranch landscapes, especially those near urban areas, is likely to grow in the United States (Hellerstein et al).

Support for rural development that is more broadly based than on-farm activities alone is an important element in the emerging EU multifunctionality debate. These 'non-farm' rural development activities are represented by the space outside the triangle but within the circle in Figure 18.1. A few broad examples of such activities are listed in the last column of Table 18.1. The first example consists of government support for communications, waste treatment and other kinds of physical infrastructure that make living and operating non-farm businesses in rural areas attractive and affordable. Non-farm businesses include ones related to agriculture, such as food processing operations. The other two examples listed consist of support for human and social capital related to education and health care in rural areas.

The focus on multifunctionality, or multiple objectives related to agriculture, is not an attempt to refute the economic notion that some policy tools may be more efficient than others in achieving different objectives or goals (Claassen et al). On the contrary, a multifunctionality approach calls for policy to be much more explicit about what we want from agriculture than has usually been the case. By so doing, analysts can more clearly identify policy tools and scenarios likely to result in either complementarity or competitiveness between agriculture's different functions.

Rather than examine the entire range of relevant policy tools, we focus in this article on positive incentive policies in the form of 'stewardship payments'. This type of policy tool is intended primarily to enhance agriculture's performance with respect to positive environmental functions, but it also can have intended or unintended effects on production and social functions. Other potential policy tools designed primarily for environmental functions, such as environmental taxes and regulations, have been extensively analysed elsewhere (e.g. Pretty et al, 2001; Ribaudo et al).

Issues Emerging from the UK Experience

Several issues emerge from examining the UK experience, and its growing emphasis on multifunctionality, that have bearing on proposals and plans to substantially expand stewardship payment programmes in Europe and the United States.

Compatibility of production support and stewardship support

Much remains to be done to completely decouple income support for farmers from production. Although there have been significant first steps in decoupling under the EU's CAP, strong incentives remain for farmers in the United Kingdom's main arable areas to continue farming intensively. UK agri-environmental schemes often have not been financially attractive to highly productive, intensive arable farms (Potter; Baldock and Mitchell). Cobb et al indicate that organic farming systems have tended to be disadvantaged relative to conventional systems in the United Kingdom because the clover/grass leys that are typical in organic rotations did not qualify for CAP arable area payments. If the ley was grazed or put up for hay or silage, it did not qualify as set-aside.[5] Bailey et al also found that eliminating or decoupling government support payments and eliminating set-aside requirements would enhance the profitability of 'integrated' crop systems relative to 'conventional' systems in the United Kingdom. Farmers in the United Kingdom's arable regions still benefit too much from production-related CAP supports to take up the higher tiers of agri-environmental schemes, and to diversify with crop rotations.

Well-intended calls for stronger safety nets in the United Kingdom tend to venture onto a slippery slope toward the area of production support. In an otherwise generally excellent discussion of policy options for UK agriculture, a report of the Royal Agricultural Society of England (RASE) justified the need for a stronger safety net, but it was vague about how such a system would be constituted. The report stated, 'any safety net should set a floor or minimum price, but is by definition coupled to production' (Royal Agricultural Society of England, p17). Authors of the RASE report suggested the possibility of using crop and revenue insurance schemes like those being tried in the United States, to strengthen the safety net for UK farmers as conventional CAP price supports are phased out. However, these schemes can inadvertently encourage overly specialized production systems if coverage is too narrow or premium subsidies are too high for particular crop or livestock enterprises. Subsidized crop insurance tends to result in expansion of cropland area (Wu). Cautions about the potential distorting effects of government-backed insurance schemes are noted in the USDA's policy statement, *Food and Agricultural Policy: Taking Stock for the New Century* (USDA, 2001).

Potter and Goodwin stress that merely abandoning production supports is unlikely to accomplish the range of stewardship objectives desired in Europe. It could, indeed, lead to less intensive production (at least after a time), thereby reducing negative externalities related to inorganic fertilizer and pesticide use. However, the overall effects on the range of features that Europeans desire in their managed agricultural landscapes are less clear. Most of the beauty and biodiversity of landscapes in the United Kingdom and elsewhere in continental Europe depend on the continuation of active farming. It is restoration or maintenance of a certain kind of farming that is desired in Europe. Liberalization of farm policy, by itself, could 'wipe out much of the human capital necessary for the effective conservation of the European countryside' (Potter and Goodwin, p291). Stated another way, decoupling of subsidy payments from specific crop and livestock commodities is a necessary, but not sufficient, condition for achieving landscape-based environmental objectives. Stewardship programmes are required to counterbalance some of the economically depressing effects that more market-oriented farm policies could have on European agriculture.

Balancing stewardship payments and environmental compliance

A critical issue facing policy makers is how to specify which environmental standards should be required without directly compensating farmers and which they should be compensated for achieving. A threefold categorization is useful in thinking about this issue (Dwyer et al). The base category consists of farming practices covered by regulations, such as restrictions on pesticide applications near waterways or on nutrient applications in the United Kingdom's Nitrate Vulnerable Zones (NVZs). The next category consists of good practices that go beyond regulatory requirements, but for which there are no agri-environmental payment programmes. Examples in England include 'retaining traditional field boundaries, or maintaining green cover over winter on erodible soils' (Dwyer et al, p32). The third category contains practices providing environmental services covered by incentive-based compensation schemes. *Cross-compliance* requirements for farmers receiving CAP production support payments could be applied to practices in either of the first two categories.

The debate about which farming practices belong in each category is both philosophical and economic. In essence, this is a debate about whether various agricultural practices that might be carried out for environmental purposes should be viewed as (1) avoidance of negative externalities or (2) production of positive externalities or public goods. What is the baseline, above which agriculture is providing positive environmental externalities and below which agriculture is *harming* the environment (producing negative externalities)? The answer in any given situation has important implications for public policy. Bromley and Hutchinson stress that this question cannot be answered objectively. The answer is inherently political, being based on public perceptions and political processes specific to time and place that determine property rights and who should provide and pay for particular environmental or social goods from agriculture.

An evolution of thinking on this question is illustrated by UK policy regarding nitrate contamination of water by agriculture. For a number of years during the 1990s, the United Kingdom implemented a Nitrate Sensitive Areas (NSAs) scheme that centred on payments to farmers for reducing or eliminating nitrate contamination. This voluntary scheme had similar features to the former Water Quality Incentive Program (WQIP) and the current Environmental Quality Incentives Program (EQIP) in the United States. Although the NSA scheme seemingly was successful (Lord et al), it is being phased out in favour of the NVZ programme. The NVZ programme is a mandatory action programme of measures for controlling nitrate concentration in surface and groundwater in vulnerable areas. Thus, the emphasis has shifted from voluntary to mandatory measures. This implies that nitrate contamination is now viewed as a negative externality, in contrast to the earlier implied view that avoidance of nitrate contamination constitutes provision of a positive externality (clean water).

United Kingdom environmental groups have argued that some environmental conditions should be attached to the CAP support payments farmers receive, i.e. that there should be cross-compliance (Potter and Goodwin; Royal Agricultural Society of England). The UK government has been considering new cross-compliance measures (Performance and Innovation Unit; Ministry of Agriculture, Fisheries and Food; Policy Commission on the Future of Farming and Food).

Environmental cross-compliance in the United Kingdom currently exists in the following:

> (*a*) The receipt of all headage payments for beef and sheep under the Sheep Annual Premium Scheme (SAPS), Beef Special Premium Scheme (BSPS), Suckler Cow Premium Scheme (SCPS), Extensification Premium and Hill Livestock Compensatory Allowances under the Less Favoured Area (LFA) scheme, is conditional on not causing significant overgrazing of the land used by livestock upon which these payments are claimed.
>
> (*b*) The receipt of Arable Area Payments, including set-aside payments, has been made conditional on farmers obeying certain conditions for the management of set-aside land … to protect habitats and species in cropped landscapes. Conditions include the retention of traditional field boundaries adjoining set-aside land, and restrictions on the timing of certain operations on the land, including ploughing and spraying, in order to minimize damage to ground-nesting birds and other species which may breed or feed in set-aside fields (Dwyer et al, pp25–26).

Dwyer et al recommended that the UK government consider several additional cross-compliance measures. One would reinforce key environmental regulations with cross-compliance conditions, such as regulations related to hedgerow and groundwater protection. A second measure would make it a general duty for farmers to observe major codes of good agricultural practice already in place in the United Kingdom. The third measure would require that farmers draw up a specified whole-farm plan. This might consist of a whole-farm conservation plan or report similar to those of the Farming and Wildlife Advisory Group in England and Scotland. The intent, however, at this stage, would not be to require farmers to implement all the plans' suggested actions. Finally, Dwyer et al recommended consideration of a cross-compliance measure requiring margins of specified widths around all fields eligible for Arable Area Payments.

As long as CAP support payments remain high, cross-compliance measures effectively serve as regulations for most farms eligible for payments. Therefore, environmental services resulting from cross-compliance are obtained with substantially less government budgetary cost than through expanded stewardship payment programmes. However, if and when production-related support payments dramatically decline or disappear in the EU, cross-compliance loses much or all of its leverage. Therefore, long-range agri-environmental planning must be based on a collective vision of which environmental conditions or outputs should be obtained through regulations and which ones should be purchased from farmers through stewardship payments.

That collective vision will emerge from interpretations and applications of the multifunctionality concept. It is quite possible, and not necessarily inconsistent, to simultaneously move in two different directions. One, exemplified by the current UK direction for nitrate externalities, requires farmers to avoid practices that clearly have adverse effects on society. The policy mix in such a polluter-pays approach could include a combination of regulations and taxes on practices and inputs that cause public harm.

The other direction, which has dominated in Europe, is to pay farmers for adopting practices that produce public goods and positive externalities – the so-called *provider-gets* principle. With this perspective, producing wildlife habitats or scenic vistas is considered to be producing a good, rather than avoiding a bad. The multifunctionality concept provides a rationale for public compensation, rather than regulation, at least some of the time. Whether a particular agricultural practice or system is viewed as producing a good or preventing a bad is clearly a matter of perspective. In the real world of policy, we are likely to see public support for paying farmers to do some things that are good for the environment, while public sentiment insists on uncompensated regulations to prevent certain practices or systems considered bad for the environment (e.g. see Policy Commission on the Future of Farming and Food).

Compatibility of world trade organization rules with stewardship schemes

As European governments shift more of their agricultural support to agri-environmental schemes, increasingly complicated issues of compatibility with WTO rules are emerging. Some in the US agricultural industry, for example, have felt that multifunctionality may be merely a protectionist ploy to continue EU subsidies under the guise of environmental protection. European economists, however, have begun systematically to examine the conditions under which stewardship payments – configured within a multifunctionality framework – may be consistent with economic efficiency criteria and what this may imply for world trade rules.

The Uruguay Round 'Agreement on Agricultural Trade' set out a series of decoupled payments that are considered compatible with WTO rules. This zone of compatibility is the so-called 'Green Box'. Payments for environmental programmes are among those that fall in the Green Box (Swinbank). However, it is not entirely clear which policies the WTO will consider to be in the Green Box as Europe advances new policies under the multifunctionality banner. Figure 18.1 seeks to bring clarity to this issue. An agri-environmental policy that is fully decoupled from production support would be in the lower right-hand corner. Such a policy would advance society's environmental goals – say, by producing positive externalities or reducing negative ones – without also increasing production. Stewardship payment schemes that provide incentives to restore hedgerows and increase field margins are good examples.

Some other agri-environmental policies are likely to be more controversial with respect to Green Box classification. There is considerable concern in Europe that the movement toward free trade, with farmers having to depend on world market prices, could 'lead to environmental decline as farmers abandon unprofitable marginal land' (Latacz-Lohmann and Hodge, p43). The European idea of managed countryside is one in which, over some range, the joint production of food and environmental goods is largely complementary, rather than competitive. If agricultural support falls too low, it may no longer be economically viable for farms in some areas to produce either conventional agricultural commodities or the kinds of rural landscape and habitats European societies value (Cahill; Latacz-Lohmann and Hodge; Swinbank). In such a situation, does an agri-environmental scheme designed to maintain multifunctional agriculture, in the Cotswold region of the west of England, for example, fall inside or outside the WTO's Green Box? A number of agri-environmental schemes in Europe may be like this – towards the stewardship support corner of Figure 18.1, but part way up the continuum running to production support. 'New World' trade negotiators tend to favour wilderness landscapes for environmental enhancement, and joint production is generally not an issue with those landscapes; 'Old World' (European) negotiators, however, place more value on lived-in, working rural landscapes (Latacz-Lohmann and Hodge).

Ervin and Mullarkey et al stress the importance of using policy instruments that minimize *trade distorting* effects when efforts are made to sustain or enhance agriculture's positive environmental functions. For example, simply maintaining an area in agricultural production may provide the desired agricultural landscape, while a higher level of crop and livestock production in that landscape may produce no additional environmental amenity (in fact, it may even decrease the amenity value) but it is more *trade distorting*. In fact, poorly designed agri-environmental programmes could inadvertently even bring more land into commodity production (Heimlich and Claassen). Latacz-Lohmann and Hodge suggest a number of ways for determining which kinds of agri-environmental policies legitimately belong in the Green Box. In essence, these suggestions call for policies that focus primarily on stewardship support while limiting, to the extent possible, *trade-distorting* commodity production and price effects. Payments should be coupled to stewardship and decoupled from production, even though, in practice, stewardship payments will sometimes cause production to be higher than it would be otherwise.

A related issue is how additionality is to be interpreted. A provision of the Uruguay Round Agreement on Agriculture limits agri-environmental payments to the extra costs of complying with government programmes (Latacz-Lohmann and Hodge). The UK Treasury also has insisted on additionality. Except in the Environmentally Sensitive Areas, simply maintaining habitat is not considered sufficient to qualify for agri-environmental payments. There must be additional public benefits beyond what is already provided by the farmer without payment. This results in troublesome contradictions: farmers who had previously removed hedgerows would be paid to restore them, but those who had maintained hedgerows at their own expense would not qualify for additional payments (Royal Agricultural Society of England). Similar contradictions plague US conservation policy. As Claassen et al (p37) indicate in their analysis of alternative agri-environmental payment approaches for the United States, if 'bad actors' can receive payments for modest environmental improvements while 'good actors' are excluded, farmers 'will be discouraged from taking any unsubsidized action that improves environmental performance'.

This issue will need to be addressed if agri-environmental policy is going to take centre stage. In our view, fairness and consistency require that all farmers are equally eligible for payments for providing particular environmental services, even if they already had been providing the services without compensation. This position does not imply that every environmental service or externality-avoidance merits compensation. It simply means that if one farmer is eligible for compensation to begin providing a service, every other farmer (in like areas and circumstances) already providing the service also would be eligible.[6] Therefore, additionality would be interpreted with respect to *normal* farming practices, not with respect to particular farms. This approach would involve specification of 'reference levels' similar to those described by Claassen et al:

> Reference levels could vary with soil type and topography, geographic region, or all of these factors. While a reference level is not an environmental baseline – it would not be

> specific to a particular farm or field – it would reflect the cropping patterns and production management or conservation practices generally in place under homogeneous soil and climate conditions. (Claassen et al, p35)

For example, if agri-environmental programmes provide payments for farmers in designated regions to use organic practices or utilize forage or green manure legume-based crop rotations, all farmers in those regions would be eligible for payments, including those who already had been farming with such systems. If this position is ruled incompatible with additionality interpretations of the WTO or other governing bodies, then those interpretations will need to be rethought. Latacz-Lohmann and Hodge suggest that Green Box criteria need to allow farmers to be paid for providing non-market environmental benefits above some reference level. If that principle is accepted, there would seem to be no valid basis for the WTO to distinguish between farmers who were already providing such benefits and those who begin providing the benefits following the initiation of a stewardship payment scheme.

An agri-environmental policy that qualifies farmers for payments who already are carrying out eligible practices or meeting established environmental criteria does not necessarily make life easy for policy makers and agri-environmental agencies. First, of course, are the budgetary implications. Making everyone eligible would be expected to add to the short run expense of providing a particular set of public environmental services. However, in the long run, government costs might not be greater, because farmers would come to see that bad environmental behaviour is not rewarded or, conversely, good environmental behaviour is not penalized.

Second, establishing what is normal and what are like circumstances is not easy, in practice. Normal rotations for one set of farms in a local area, for example, may vary from what is normal for other farms in the same vicinity because of subtle differences in biophysical circumstances. There are substantial administrative costs in taking all of these circumstances into account to establish and implement agri-environmental programme eligibility criteria. Using eligibility criteria derived from comparisons of what is additional relative to normal farming practices is feasible, but not without difficulty.

Agri-environmental issues are on the agenda for the new round of WTO negotiations that was approved in Doha, Qatar in November 2001. Even under current WTO rules, policies to support environmental objectives in agriculture are allowed if they are only 'minimally trade distorting' (Normile, p80). How much is minimal is likely to be contested.

Implications for US Policies

In spite of some differences in perspective, 'the European Union and the United States are coming closer together in the policy issues that they will have to address'

(Blandford, p17). Further, substantial policy reforms are required on both sides of the Atlantic to accomplish shared goals. This means that European and North American policy makers must be willing to learn from the past and from one another as they develop new directions for agri-environmental policy.

There was much discussion and debate about the scope and form of conservation and agri-environmental programmes in the process of developing the latest US 'farm bill', the Farm Security and Rural Investment Act of 2002. This Act authorizes a ten-year expenditure plan for the US agricultural sector that calls for an 80 per cent increase in spending on conservation and environmental programmes (compared with a baseline projection under previous programmes and policies) (USDA, 2002). However, production-related price and income supports also have been continued and expanded, with expenditure increases over ten years expected to be nearly four times the amount of conservation expenditure increases.[7]

It seems evident from experiences on both sides of the Atlantic that for agri-environmental policies to be fully effective, the decoupling of income supports from production must be completed. Such a decoupling clearly did not come about in the United States's 2002 farm bill. If anything, there was some recoupling, in that a new system of counter-cyclical payments tied to target prices and updated base acres and crop yields was established (USDA, 2002). This support mechanism is very similar to the old target price/deficiency payment mechanism done away with in the 1996 farm bill.

Even under the 1996 farm bill – with its planting flexibility provisions, as well as conservation compliance provisions going back to the 1985 farm bill – Corn Belt farmers remained too tied to production-related supports to diversify out of the narrow and inherently chemical-intensive corn-soybean rotation. Between 1996 and 2000, soybean acreage increased in several Corn Belt States, while corn acreage stayed about the same or decreased slightly (Commission on 21st Century Production Agriculture). Some land shifted from continuous corn production to the corn-soybean rotation, but there was little shift to more diverse rotations incorporating forage or green manure legumes.[8] Although many Corn Belt farmers have adopted 'best management practices' intended to reduce environmental damages, they had little impact on inorganic fertilizer and pesticide loadings (Caswell et al). Since the structure of agriculture has evolved over the last several decades toward larger farms and fewer market outlets for forages and other products of diverse crop rotations (Dobbs and Dumke; Dumke and Dobbs), decoupling alone may be insufficient to bring about much increase in diversity and reduction in chemical intensity – unless, perhaps, one is thinking in decades, instead of years. This is true in both England's East Anglia and the American Corn Belt. The continuation of major production-related supports under both the EU CAP and US farm bills makes it much more expensive and difficult for agri-environmental programmes to be effective.

At the same time, it must be recognized that dramatic reductions in, or actual elimination of, price or income supports in the United States could result in the sacrifice of some environmental gains achieved as a result of conservation compliance if there is not sufficient expansion of regulations or stewardship payments (or both). The evolution of UK agri-environmental policies toward nitrate contamination illustrates the kind of decisions that will need to be made if there is less US reliance on conservation compliance in the future. As described previously in this article, that evolution implied a more clear delineation of which kinds of agricultural externalities will, for policy purposes, be considered subject to the polluter-pays principle (in this UK case, nitrate contamination) and which ones will be subject to the provider-gets principle. If conservation compliance were to lose its leverage in fostering the kinds of basic soil conservation and wetland protection called for in US farm bills since 1985, it would be necessary to decide if the former compliance levels really are baselines, subject to uncompensated regulations, or if they are to be maintained by expanded stewardship payment programmes.

The most significant expansion in stewardship payment programme funding in the 2002 US farm bill is for the EQIP, but the most significant new programme form is the Conservation Security Program (CSP). This programme has features similar to some of those that have existed in UK agri-environmental programmes, with different payment 'tiers' based on the nature and scope of environmental practice or system changes. Unlike the Conservation Reserve Program, which takes land out of conventional crop and livestock production in order to focus exclusively on environmental goods, the CSP is designed for *working lands*. The CSP constitutes an attempt to foster multifunctionality by leaving land in crop and livestock production and providing stewardship payments for the use of practices and systems intended to reduce negative environmental externalities or, conversely, increase positive ones.

Tier I of the CSP, the lowest tier in terms of conservation requirements and payment rates, focuses primarily on individual practices. Tier II, with payment rates higher than those for Tier I, requires enrolled farmers to deal with 'at least one significant resource of concern for the entire agricultural operation' (Conservation Security Program, pp6–7). The highest payment rates are for Tier III, which requires application of a 'resource management system that meets the appropriate nondegradation standard for all resources of concern of the entire agricultural operation' (Conservation Security Program, p7). Based on the UK experience with tiered agri-environmental schemes, one of the major challenges to US policy makers will be to induce farmers in the more productive agricultural areas into the higher tiers, especially, in this case, Tier III. Given the continuation of high price and income supports tied directly or indirectly to narrow, intensive crop systems, it is likely to prove either difficult or very expensive to induce participation in whole-farm resource management plans that actually involve very much change in farmers' systems. Changes involving resource conserving crop rotations (listed among the CSP's eligible conservation practices) could prove especially difficult to induce.

Although the whole-farm orientation of the CSP's Tier II and (especially) Tier III represents an European-like broadening of US agri-environmental policy, the legislative language implies a more narrow multifunctionality orientation than some of the latest European agri-environmental schemes (Conservation Security Program). The CSP could be used to foster bird habitat and biological diversity, as in UK agri-environmental schemes; eligible practices include fish and wildlife habitat conservation, restoration and management. However, rural landscape priorities, which have been central to major UK agri-environmental schemes, are not particularly evident in other types of conservation practices (nutrient management, integrated pest management, water conservation and water quality management, energy conservation measures, contour farming etc.) listed as appropriate for CSP contracts. Moreover, the legislative language does not suggest much emphasis on promoting regional social and economic objectives, as do recently introduced European schemes like England's Land Management Initiatives (Countryside Agency) and France's Contrat Territoriale d'Exploitation (CTE, or Territorial Contract of Farming) (Dwyer, 1999, 2000). Such an emphasis does not seem precluded, though, as enhanced CSP payments are allowed if participating farmers 'address local conservation priorities' or participate in 'a watershed or regional resource conservation plan that involves at least 75 per cent of producers in a targeted area' (Conservation Security Program, p10). If the CSP were to evolve in the direction of a much broader multifunctionality, it would be valuable for US policy analysts to monitor lessons learned during implementation of relatively new schemes like the Norfolk Area Land Management Initiative, which combines regional and whole-farm planning in the east of England.

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Notes

1 These percentages are shifts of funds from traditional production-type CAP supports to rural development and agri-environmental programmes, and do not represent the total percentage of the agricultural budget devoted to rural development and agri-environmental programmes. At the present time, the second CAP pillar – covering rural development and agri-environmental measures – commands only around 10 per cent of the overall EU CAP budget (Baldock and Bennett).

2 See Dobbs and Pretty for a more complete discussion of issues associated with the UK experience, including: opportunities for programmes to contribute jointly to social and stewardship objectives; capitalization of scheme benefits into land values; and how to gain from bottom-up planning and subsidiarity.
3 See Dobbs for a distinction between changes in farming practices and changes in farming systems.
4 Bromley refers to these as amenities and habitat.
5 Based on perceived benefits to the environment, organic agriculture has been aggressively promoted under the United Kingdom's Organic Farming Scheme. Preliminary case study evidence reported by O'Riordan and Cobb supports the existence of at least some of those perceived benefits, relative to 'conventional' agriculture.
6 This does not imply that farmers in all regions of a country would necessarily qualify for given environmental practices or performance. For example, farmers utilizing a particular agricultural practice or system might qualify for incentive payments in a watershed threatened by soil erosion, but not qualify in another watershed or region of the same country if it is not so threatened. That is a separate issue of 'spatial targeting' (Claassen et al).
7 Preliminary estimates by the Food and Agricultural Policy Research Institute (FAPRI) indicated that net outlays on commodity programmes could increase by $49.7 billion over ten years (compared with a baseline with previous farm bill provisions), and the projected increase was $13.2 billion for conservation programmes (United States Senate Committee on Agriculture, Nutrition & Forestry).
8 It has long been known that cropping systems that include regular rotation of forage and green manure legumes contribute greatly to the creation of the soil's natural capital (Balfour; Daily; Doran and Werner; Peterson et al; Power; Pretty, 1998, 2002).

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19

Ways Forward? Technical Choices, Intervention Strategies and Policy Options

Camilla Toulmin and Ian Scoones

Introduction

This book has emphasized the importance of taking local contexts seriously. The case studies have revealed the importance of dynamics and diversity in all farming settings across all three countries. Some of the key findings are summarized below.

- Farmers have criteria for classifying soils, such as their workability, inherent fertility, suitability for certain crops, responsiveness to particular inputs and water-holding capacity. Farmers actively manage their soils in ways that build on these characteristics with the aim, over time, of thus improving their value for crop production.
- Africa's farming systems are highly diverse. This diversity is an important feature at all scales. At household level, farmers manage this diversity by different land use practices, choice of crop and input levels. Diversity at the level of the village landscape is exploited through use, for example, of low-lying areas (variously known in the study areas as *bas fonds, vleis, dambos*), for moisture-loving crops, upland sands for millets and groundnuts, and gravelly slopes for grazing and woodland. Farmers value such diversity since it provides greater protection against the risk of crop failure. Diversity at national level is seen in the differential development of areas considered of high and low potential, infrastructural investment and ease of access to important markets.
- Farming systems are dynamic, responding to a range of internal and external pressures. Reliance on data from nutrient balances provides only a snapshot at one point in time, from which the direction and evolution of the farming system in question are hard to determine. There is no single pathway being followed by all farmers in a given site, but rather an array of directions being

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taken depending on their circumstances. Farmers are constantly seeking new strategies as problems arise or new opportunities develop.

- Farmers' management of soil nutrients depends on a range of socioeconomic factors. Access to livestock, labour, credit and markets are of particular importance in explaining which farmers are best able to maintain and improve the fertility of their soils. The household remains central to the management of the farm and the mobilization of resources, such as labour and capital. However, other social institutions are also of great value in enabling farmers to negotiate access to obtain resources such as draft power, transport and credit. Such institutions also help farmers protect themselves from risk by the development of social networks through which help can be sought in times of need.
- Data on nutrient balances demonstrate a mixed pattern of accumulation and depletion, depending on plot, farmer and location. Overall, cash-crop land receives the major share of both mineral and organic fertilizers applied. Land sown to lower-value crops, such as coarse grains, shows a consistently negative nutrient balance. However, due to rotation of crops, cereal yields can often benefit from residual fertility stemming from the previous year. Location of plots is also important, with land close to the settlement or cattle pen receiving most nutrient inputs.
- Farmers in all sites have been affected by recent policy changes, such as structural adjustment, devaluation and land tenure reforms, as well as exogenous events such as drought. Such changes have brought about major shifts in returns to different crops, as well as the liberalization of crop marketing. Farmers are clearly responsive to such positive changes, which implies that governments have a range of measures by which to influence farmers' decision making. This range of policy options is discussed in more detail below.

Given this diversity of local contexts and the complex dynamics of soil-fertility change, what is the most appropriate way to identify options by which to support more sustainable soil management by smallholders in Africa's more marginal farming areas? Such options must combine different elements: technical choices, strategies for intervention and a range of policy measures. The remainder of the chapter sets out to explore this question. First, the particular incentives – operating at a range of scales from the household to the village to the national context – for farmers to invest in soil-fertility management are discussed. These factors condition the range of technical choices that farmers make. The following section looks at the variety of ways farmers can and do manage their soil fertility and the implications this has for intervention strategies by governments, donors and others. The success of such strategies are seen to be affected by agroecological conditions, household and community-level institutional arrangements, and national policies in a range of areas. It is these policy themes which are then picked up in the following section, when issues of devaluation and structural adjustment, credit, rural infrastructure, research and extension services, and land and tenure reform and decentralization are discussed. A wide range of policies, therefore, are seen to affect soil-fertility management. But how should initiatives directed towards soil-fertility issues be directed? The final section looks at the options, and suggests a strategy which recognizes the multiple dimensions of soil-fertility management, and a process which establishes a more open learning, adaptive process for the design, monitoring and evaluation of policy measures.

Diversity of Agroecological Setting and Farmer Practice

The conditions faced by farmers in sub-Saharan Africa are remarkably diverse. The research sites were chosen to investigate the significance of such diversity for farmer practice. Thus, the sites selected spanned a long transect in Mali from irrigated Tissana and millet-based Siguiné to M'Péresso in the cotton belt, from highland to lowland farming villages in Wolayta, southern Ethiopia, and from high potential Mangwende to Chivi in the low potential region of Zimbabwe. This diversity across the continent and within the different countries studied is mirrored at village level. The options available to poor farmers are much more constrained than those available to richer farmers who have easier access to labour, land, livestock, credit and cash. This theme of diversity can be taken further to farm level, where the management of soils within the farm varies very considerably between parts of the farm. Typically, certain fields tend to receive far greater concentrations of labour and nutrient inputs, while others are more extensively managed. Thus, in Zimbabwe, homefields close to the settlement receive most attention while outfields have limited applications; in Ethiopia, the *darkoa* plots supporting dense stands of enset receive regular supplies of manure and household waste, while further afield maize crops on the *shoka* plot have to make do with little or no amendments to the soil. Similarly, in land-extensive dryland sites in Mali, the *soforo* infields around the village are often black with dung by the end of the dry season and offer well-fertilized conditions for crops of maize and millet. By contrast, the large, shifting outfields, or *kongoforo*, produce a harvest for four or five years before being abandoned to fallow and occasional grazing. Where cotton has become important, the availability of chemical fertilizer modifies this pattern and enables more permanent cultivation of larger bush fields.

This diversity at different scales has very important implications for how best to support improved farmer management of soil fertility. There are no simple messages regarding appropriate ways to manage Africa's soils. While depletion or 'mining' of nutrients may constitute a problem for certain fields, there are others which are accumulating nutrients. The research has helped identify the locations in which soil-fertility management has become a key issue. Villages such as Siguiné in Mali can still manage a system of fallowing and nutrient transfers from grazing in crop land and thereby maintain grain yields, albeit at low levels. For them, low and erratic rainfall and uncertain prices are at least as much constraints on assuring food security as the fertility of their soils. The sites in Ethiopia demonstrate a relatively efficient system of managing and recycling of biomass and nutrients, although these are tightly constrained by limited access to markets, poor veterinary services and the high cost of mineral fertilizer. In Zimbabwe, the two locations demonstrated marked differences in terms of their productivity and market access. Mangwende is in a relatively high-potential area, with reasonable rainfall although poor soils, and is well connected to markets in Harare and Chitungwiza. By contrast, Chivi is in a semi-arid zone where frequent droughts reduce productive potential. Although there are good road connections to Masvingo to the north and South Africa to the south, there are fewer market opportunities.

The research on differences in soil-fertility management between socioeconomic groups has helped identify households for which soil-nutrient decline constitutes a serious problem. Poorer households in all sites faced particular difficulties in maintaining the productivity of their farmland, due to very limited supplies of livestock dung and poor access to credit and inorganic fertilizer. Such difficulties are a reflection of their limited assets and capacity to mobilize resources more generally. Poor farmers in Dilaba, Mali and Chivi, Zimbabwe were additionally constrained by the disappearance of fallow land and lack of access to credit. This diversity has major implications for design of technical options, extension approaches and policy frameworks for improving soil-fertility management.

Farmers' Concern for Soil-Fertility Management: The Broader Context

As the case studies have shown, the capacity of different farmers to invest in improving soil-fertility management depends on a range of factors which operate at different levels. For the household, these factors include access to labour, livestock, land, capital and cash. In all sites, better-off farmers were much better able to invest in larger-scale use of organic and inorganic sources of nutrients. For example, in some sites, having some means of transport, such as a cart, is also critically important in allowing large quantities of biomass to be moved to and from homestead, *kraal* and crop lands. But there was also great diversity in how such inputs are used, since farmers do not spread them universally across all fields and crops. Instead, nutrients tend to be focused on smaller plots of land where higher-value crops (such as vegetables) are grown. In addition, rotation of land spreads fertility inputs over a series of years. For cotton farmers in southern Mali, nutrient inputs were positive for cotton in the year in which cotton is cultivated, but if account is taken of the subsequent two years of rotation with maize, millet, and sorghum, then over three years there is a net outflow of nutrients. Nutrient losses are much more significant on fields where lesser-value crops are grown and which are not a high priority for farmers. However, even here, farmers often make very effective use of the very limited quantities of nutrients available through careful placing and timing of such inputs in relation to rainfall and crop development. In all sites, farmers were experimenting with very small additions of mineral fertilizer at sowing or weeding time to gain some benefit at limited cost. At the village level, issues include the range of soils available, the overall pressure on farm land and its availability, access to grazing and forage resources, and the importance of labour flows between households, as well as location in relation to markets. At the national level, factors of relevance relate to macro-economic policy, input–output prices, access to credit, institutions and legislation regarding land tenure and its management, approaches to research and extension policy, marketing and infrastructural investment.

Our research approach used a range of methods to discuss the importance of such factors at farm-household, village and national levels. Interviews with farmers regarding family histories and changes in soil-fertility management practices have brought out the combined importance of changes at household level (such as access to labour, livestock assets and off-farm income sources), and broader economic and institutional factors (such as major shifts in prices following devaluation, and land tenure reorganization). This interplay of household, village and macro-level factors helps explain the differences in performance between different farmers at the time of the research. However, it was also clear from the family and village histories that farmers' strategies are dynamic and continually adapting to a range of new problems, as well as the opening up of better opportunities both in agriculture and elsewhere. In some cases, major events such as drought in Zimbabwe have caused significant changes to the farming system due to reduced supplies of manure following heavy cattle losses. In others, a coincidence of good fortune at family level and the development of profitable options for crop production can enable particular farmers to improve their situation greatly. Thus, for example, the growth of horticulture in the Mangwende site in Zimbabwe has been the result of the growth of urban demand for vegetables and fruit in Harare. Those who have access to wetland areas, labour and reliable transport are able to cash in on this new market. Equally, some farmers in the irrigated rice village of Tissana, Mali were able to gain a large allocation of land within the scheme, because they had a large number of family members at the moment of land allocation. Such land has become increasingly valuable with the growth in vegetable gardening and marketing.

At the same time, the research also demonstrates that maintaining and improving the fertility of their soils is only one among a range of objectives which farmers are pursuing. Farmers are faced with many important choices relating to their farm enterprise, other economic activities and domestic commitments. The decision by farmers to invest effort and capital in improving the soils and productivity of their farmland will depend, in part, on pressures to do so, the perception that changes are necessary and the lack of other options. But it will also depend on their confidence that the returns will be worth it. Soil degradation and nutrient losses are unlikely to prompt changes in farmer behaviour until and unless they perceive clear benefits from doing so.

Exploiting soil capital is a rational strategy for farmers to pursue where the nutrients remain to be tapped and where clearing new land for such purposes is cheaper and easier than investing in purchase of inorganic inputs, or in the considerable amount of labour needed to recycle biomass through manuring and composting systems. Such extensive strategies are clearly apparent in Siguiné, Mali. Farmers are likely to moderate such 'soil mining' where they see declining yields and where they depend on this land for future harvests. Cotton farmers in M'Peresso, Mali are starting to engage in much more intensive nutrient management, following similar patterns as those in the more nutrient scarce sites of Ethiopia and Zimbabwe studied here.

Efforts to 'recapitalize Africa's soils' and to replenish soil fertility need to take into account the broad-based nature of the farm household enterprise. This means that farmers have to weigh up the advantages of investing further effort in improved soil management in comparison with the much broader range of decisions they face, such as the gains from allocating labour to migration, more time spent on trading activities and the need to allocate resources for a forthcoming wedding. This finding points to the importance of setting soil-fertility management within a broader livelihoods approach (Carney, 1998; Scoones, 1998), a theme picked up later in this chapter.

Technological Choices

If the ultimate goal of intervention in soil-fertility management is to increase useful outputs for improving livelihoods, there are a variety of routes to do so, each with differing technological choices. Table 19.1 identifies four clusters of technological options. One focuses directly on the soil resource, by attempting to improve

Table 19.1 *Technology choices for managing stocks and flows of nutrients*

Managing stocks	*Managing external flows*		*Managing internal flows*
Increasing nutrient stocks	*Increasing nutrient inputs*	*Decreasing nutrient outputs*	*Increasing nutrient use efficiency*
P – Recapitalization through rock phosphate or other P additions	Inorganic fertilizer	Erosion control	Composting; residue recycling
	Manure/urine N-fixation (legumes)	Reduce leaching (mulching, deep capture through agroforestry, tillage systems)	Water management
N – Organic matter build-up	Fallowing, green manure, agroforestry etc		Crop choice and management
	Biomass import (leaf litter etc)	Reduce volatilization (manure/urine management)	Fertility input combinations Input placement and synchronization

Source: Scoones and Toulmin, 1999

the capital stock, and thereby the service flows derived from it. The other three focus more on the flows themselves, either reducing losses, increasing inputs or improving efficiencies of nutrient use.

An approach aimed at increasing inputs and reducing outputs suggests a set of interventions, ranging from fertilizer application or soil conservation measures, through a range of biological management approaches, involving agroforestry, green manure production, legume use and so on. The details of such technologies are well known, and many combinations have been tested in field settings across Africa.[1] To different degrees, all options are evident in the different case study sites. Depending on the agroecology of the site, the asset base of the farmer and the institutional and policy context, different options have been picked up and used, singly or in combination.

A number of common elements can be found in the current research and extension activities being pursued in each of the countries studied. In most sites, extension recommendations are dominated by inorganic fertilizer recommendations. Where organic amendments are part of the extension package, they often recommend unfeasibly high levels of application rates.[2] In some sites, particularly as a result of NGO and research projects, a wider range of technologies for increasing nutrient inputs have been tested. For example, all sites have had composting pits tried out, alongside a range of agroforestry options. However, in most cases a simple transfer of technical design to a range of farmer settings has resulted in limited uptake. Thus, for example, in the lowland Ethiopian site, the multiple pit composting system recommended by the Ministry of Agriculture was quickly abandoned in favour of a simpler technology. Similarly, the alley farming techniques which had been promoted were also rejected by farmers, in favour of planting trees in homesteads and along field boundaries. In southern Mali, by contrast, considerable effort has been made by researchers and extension workers over recent years to help farmers develop organic fertilizer production through a variety of means, including composting, which provides organic materials for farmers with few or no livestock. In this way, research has aimed to address the obvious differences in assets and constraints faced by poorer and richer households.

Direct investment in the capital stock of a soil through recapitalization is an approach which has recently been widely advocated (Sanchez et al, 1997). In terms of technologies, this may involve the application of rock phosphate to enhance phosphorous stocks and the use of nitrogen-enriched fallows for nitrogen recapitalization. This has seen little application in the case study sites, although rock phosphate options are being explored in both Mali and Zimbabwe. However, the degree to which such additions may act to recapitalize natural capital or act as a cheap supplementary amendment (perhaps in combination with organic sources) is unclear. For most farmers, such technical solutions are not part of their current repertoire. Their means of increasing capital stocks has rather been through the painstaking, labour-intensive process of continuous fertilization and cultivation. This, as the case studies have shown, takes place largely in gardens and homefield sites where the large bulk of organic matter is placed. For other plots, the options for recapitalization are limited due to limited resources, so that farmers can only hope, at best, to maintain crop yield at a fairly low level.

All sites have experienced various attempts at soil erosion control. In many cases a top-down approach to technical design and implementation has resulted in a great deal of resentment. While farmers readily recognize the importance of stemming nutrient losses through erosion control, the imposition of fixed contour bunds or terraces has not been widely welcomed. Thus, for example, in Zimbabwe, the colonial attempts at soil erosion control became a focus for nationalist opposition during the liberation war of the 1970s, and in Ethiopia, after the fall of the Derg, many farmers dug up their terraces and replaced them with more flexibly designed and less land-consuming alternatives. In the cotton zone in Mali, the CMDT in collaboration with researchers have incorporated soil-erosion control as a central part of their support to cotton farmers in Mali Sud (Hijkoop et al, 1991). This has had considerable success in reducing erosion losses and protecting the income streams of cotton farmers.

More sensitive approaches to land husbandry and soil conservation have emerged in the last decade, which draw more explicitly on farmers' own techniques for managing soils. These often combine the management of soil, water and nutrients in combination, rather than isolating soil erosion as the main issue (see examples in Reij et al, 1996). Combining physical with biological conservation measures and changes in tillage practice perhaps offers the most promising route for tailored interventions in this area. For example, in Zimbabwe research on conservation tillage has been combined with more conventional approaches to soil conservation and newer approaches to agroforestry and biomass management on-farm to come up with a variety of technical options.

Improving the efficiency with which nutrients are used is less often considered when choosing among a range of technological options, but is nevertheless vitally important (Nordwijk, 1998). For instance, application efficiency is sensitive to changes in the mix of inputs applied, where they are placed in relation to the plant, and timing of application in relation to moisture availability and plant requirements at different stages of growth (Woomer and Swift, 1994). A decline or improvement in use efficiency may make big differences in useful output, without any change in inputs, outputs or nutrient stock levels, and so can help to offset the effect of a decline in available nutrients and depletion of stocks for a period. For example, work in Zimbabwe has shown that a very limited amount of fertilizer input, perhaps combined with small amounts of manure, if placed in a particular way and at a time which maximizes uptake efficiency, can produce very significant yield responses, possibly far higher than a general application of an input in a blanket manner (Piha, 1993).

This suite of technological options for improving stocks and managing the flows of nutrients can be applied in a variety of ways. Four different intervention strategies can be pursued, either singly or in combination (Scoones and Toulmin, 1999).

1 One-time soil recapitalization strategy, especially of phosphorous using rock phosphate.
2 High external-input strategy, based on the use of inorganic fertilizer packages.
3 Low external-input strategy, based principally on the use of locally available organic resources.
4 An integrated soil-fertility management strategy, making use of a range of high and low external-input technologies in combination.

A variety of conditions make any one or combination of such strategies more likely in any particular setting (Table 19.2). These include agroecological factors (such as soil type or biomass availability/productivity), household level conditions (such as labour or cash availability), and broader policy conditions (relating to prices, markets, credit, infrastructure and extension support).

The diversity of soils, cropping patterns and management practices within a single farm holding and the dynamic nature of soil-fertility and farming-system change sets a challenge for researchers and policy makers. Diversity of strategy at farmer level implies an approach to intervention which is highly localized and involves farmers in identifying, monitoring and evaluating different interventions for improving systems for soil-fertility management. This requires a flexible and responsive policy environment to support processes of technological innovation and investment in soil-fertility management. Table 19.2 indicates that a number of policy areas influence the likelihood of adoption of different options for soil-fertility management. It is to these issues which we now turn.

Impacts of Policy on Farmer Practice

Farmers in all three countries studied have been affected by a range of policy measures which have influenced crop choice, input use and broader livelihood strategies. Table 19.3 summarizes the range of policy interventions and their impact in the study areas. Five broad policy areas were identified in the case study research as having particularly significant impacts on soil-fertility management: structural adjustment (relating particularly to input–output pricing and marketing); credit; rural infrastructure; research and extension services; and land and tenure reform and decentralization. These are discussed in more detail below.

Devaluation and structural adjustment

In each of the three countries, there have been considerable changes in macroeconomic conditions and broader policies, linked most particularly to programmes of structural adjustment which have shifted substantially the terms of trade and incentives faced by farmers. However, the timing and nature of changes wrought

Table 19.2 *Key conditions for four intervention strategies*

Key conditions	*Recapitalization of nutrient stocks (one-time)*	*High external inputs (especially inorganic fertilizers)*	*Low external inputs (especially organic matter management)*	*Mixed strategy: integrated nutrient management*
Soil type and limiting nutrients	Appropriate for P limited soils, less so when N limited.	Any: fertilizer mix can be adapted to particular soil and plant needs	Most effective for N limited soils, through build up of organic matter	Any
Biomass availability	na	na	High	Variable
Labour requirements	High initial input	Low	High	Variable
Financial costs – credit or subsidy requirements	High	High	Low	Variable
Farmers' skill levels required – requirements for extension support	Low	Low	Medium	High
Need for good infrastructural/market links for input supply	High	High	Low	Medium
Potentially negative environmental or health impacts	Yes	Yes	No	Limited
Intervention focus	Input importation; transport; implementation logistics; farmer and area targeting	Soil testing; fertilizer manufacture, blending; demonstration plots; input prices and markets	Appropriate technology development; training	Local experimentation; researcher–farmer participation; skills training; 'field schools'

Source: Scoones and Toulmin, 1999

Table 19.3 *Impacts of policy on soils management in Ethiopia, Mali and Zimbabwe*

	Ethiopia		*Mali*		*Zimbabwe*	
	Policy context	*Policy impacts*	*Policy context*	*Policy impacts*	*Policy context*	*Policy impacts*
Input–output pricing	Liberalization and devaluation from 1991; subsidies on fertilizers removed 1997. Currency devaluation from early 1990s.	Real prices of both inputs and outputs increased, although profitability of inputs use constrained.	Structural adjustment from 1982 onwards, removal of subsidies for fertilizer and other inputs, abolition of credit programmes. Restructuring of CMDT Office du Niger. Devaluation of CFA, 1994.	Liberalization of cereal markets, input prices up, food price increases, loss of access to credit.	Liberalization from 1991, with removal of all subsidies. Regular devaluations of Zimbabwe dollar since 1991.	Prices of inputs and outputs have risen, with price ratios remaining approximately similar. High value crops (e.g. vegetables, some cash crops) have become more profitable.
Marketing	Well-established informal markets; fertilizers sold through regional trading companies and private suppliers from mid-1990s.	Limited growth of private sector marketing, with negative impacts on prices for farmers. Reliance on extension or project supply of inputs through credit programmes.	Abolition of state cereal board, liberalization of cereal markets, including rice. Private input supply outside cotton growing area.	Growth in private trade, cereals and vegetables increased opportunities for farmers. Cotton remains a government monopoly through CMDT.	Effective privatization of marketing boards, and encouragement of private trade.	Growth of private trading has had positive impacts in the higher potential areas, but less so in lower potential sites where profit margins are lower. Here, growth of contract arrangements has occurred.

Table 19.3 *(continued)*

	Ethiopia		*Mali*		*Zimbabwe*	
	Policy context	*Policy impacts*	*Policy context*	*Policy impacts*	*Policy context*	*Policy impacts*
Credit	Range of informal credit options; bank credit limited; agricultural input credit focused on package programme.	Formal credit largely inappropriate for poorer farmers; package programme results in increased debt burden for poorer farmers and in marginal areas.	Formal credit available only to cotton farmers through village associations. No more credit provided by Office du Niger.	Cotton farmers continue to gain credit for input purchase. Rice farmers rely on private sector. Cereal farmers access informal sources, off-farm cash and NGO credit funds.	From early 1980s, limited availability of formal credit.	Credit a major constraint for many farmers.
Rural infrastructure	Poor road infrastructure, but significant investments since 1991.	Improved transport and marketing opportunities for remoter areas.	Gradual extension and upgrading of main road network. Little improvement in feeder roads.	Farmers near main roads face much cheaper transport to markets, many others rely on carts, donkeys, walking.	Since independence in 1980, major investments in rural road building.	Transportation and marketing is now easier, although costs have increased due to fuel price increases caused by devaluation.

Table 19.3 *(continued)*

	Ethiopia		*Mali*		*Zimbabwe*	
	Policy context	*Policy impacts*	*Policy context*	*Policy impacts*	*Policy context*	*Policy impacts*
Research and extension services	Research service undergoing reform, although current focus on limited technical options; extension dominated by package programme.	Much research inappropriate for poorer farmers, with resulting limited impact. Focus of extension service on package programme also excludes many.	Government research on agriculture under reform. Funding cut and shift to greater client orientation. Main focus has been raising yields of cotton and rice, from technical standpoint. Low potential areas receive no systematic attention, though occasional NGO projects.	Considerable impacts from research and extension for rice and cotton. Increasing attention to diversity of farmer strategies and messages. Very limited impacts of research for dryland cereals.	Research and extension switched emphasis to the smallholder sector following independence. However, significant budget cuts and a continued narrow technical focus have limited the ability of government services to respond to farmer needs.	Research has had limited impact on farmer strategies. The impact of a reduction in extension provision is unclear. Emergence of project-funded research and extension activities has had important, but limited, effects in certain areas.

Table 19.3 *(continued)*

	Ethiopia		*Mali*		*Zimbabwe*	
	Policy context	*Policy impacts*	*Policy context*	*Policy impacts*	*Policy context*	*Policy impacts*
Land tenure	Land owned by the state; no changes in formal land tenure regime expected.	Variable perceptions of land tenure security, although from late 1980s growing evidence of land-based investments. Various forms of land exchange, tenancy, share cropping etc persist.	Land taken as national asset post-independence, with free access for all. Current land tenure reforms allocate responsibilities to rural councils, who may attribute powers of management to village-level structures. Putting land to good use the basis for acquiring rights.	Lack of clarity regarding powers to manage and control access, most marked for common property grazing, woodland, unfarmed areas. Fairly secure tenure farmland through customary systems. Relations unclear between communes rurales (CRs) and village-level structures.	All communal lands remain state property, with rights to distribution now held by rural district councils and local traditional authorities, and recently land councils.	De facto land tenure involves a high level of security in communal areas. Recent emergence of an (illegal) land market in some areas, as well as land invasions.

Table 19.3 *(continued)*

	Ethiopia		*Mali*		*Zimbabwe*	
	Policy context	*Policy impacts*	*Policy context*	*Policy impacts*	*Policy context*	*Policy impacts*
Land reform and resettlement	In past forced resettlement and villagization carried out; currently some discussion of further land reorganization.	Uncertainty over future intentions results in insecurity.	Uncertainty regarding rights and roles of CRs and village-level structures.	Future tensions and confusion likely between powers of CRs and customary structures at village level.	Land reform has been a central pillar of post-independence policy, but until 2000–2001 limited progress had been made.	Land reform and resettlement has had limited impact on farmers in most communal areas.
Decentralization	Regionalization a central policy thrust.	Opportunities for tailored regional programmes and policies, although limited capacities and continued influence of national directives undermine options.	Process of preparation over last 5 years, elections held May 1999. Heavy donor pressure, political control and service delivery the main reasons for decentralization.	Too early to judge. Clarity needed regarding CPR management, rights and roles of CRs and village-level structures.	Decentralization to rural district councils has been ongoing since the 1980s. Lower level development committees at village and ward level were established.	Much of the process of decentralization has involved deconcentration, with resulting reductions in services offered at local level. Village and district authorities have relatively little authority and influence.

by such measures have differed considerably between countries, as have some of the impacts. For example, Mali was one of the first countries in Africa to engage in structural adjustment from 1982 onwards, whereas Ethiopia has only recently begun to cut back on fertilizer subsidies. Overall, structural adjustment measures have led to the rising cost and reduced availability of chemical fertilizer, cutbacks in extension services and changes to crop marketing structures. However, while some farmers (such as those engaged in cash cropping, and those who depend on extension advice) have felt the impacts of such changes fairly immediately, others have been less closely affected because of their greater autonomy.

In Zimbabwe, the Economic Structural Adjustment Programme (ESAP) was introduced in 1991, resulting in changes to marketing, provision of services and input–output prices. These have brought about a major shift in use of inputs and choice of crops, leading to diversification and modifications to land use management (Government of Zimbabwe, 1998). The impact of ESAP was particularly harsh since its implementation coincided with the severe drought of 1991–1992, during which a high proportion of livestock died. Hence, for example, farmers in the drier area of Chivi lost 60 per cent of their cattle holdings, drastically cutting the availability of manure for maintenance of soil fertility. As a result, Chivi farmers have greatly reduced capacity to maintain soil fertility and must concentrate the limited amounts available on their most important crops. The liberalization of grain marketing means that farmers are no longer obliged to sell their maize at a fixed price to the Grain Marketing Board, which now just sets a floor price at which it can constitute essential stocks in case of future shortage (FSRU, 1998). As a result, farmers are exposed to potential gains, but also risks associated with the private trading sector. Private traders are now starting to engage in provision of inputs to farmers for particular crops, thereby establishing an alternative input and marketing channel. Contracts with traders are of greater importance in the higher-potential Mangwende for cotton and vegetables, but, even in Chivi, some farmers are now regularly growing peppers and other vegetables for purchase by traders. In general, less grain is now being grown, with farmers resorting to vegetable gardening which has higher returns per hectare (FSRU, 1998). Limited nutrient inputs are focused on gardens in homefields, or those being established along river banks. With fewer livestock available, there has been a return for many to hoe agriculture, and greater attention paid to incorporation of plant matter within ridge and mounding systems.

Zimbabwean farmers' perceptions of the ESAP are mixed, as might be expected, depending on their access to resources and the opportunities they can gain from changes in prices and markets. In Chivi, farmers' perceptions are universally negative:

> Those who are richer get richer, and those who are poor become poorer... ESAP is like AIDS – it kills you slowly, but surely... farmers cannot benefit fully from market liberalization because the markets fix prices at levels which are disappointingly low... (FSRU, 1998, p458)

In Mangwende, there is more of a contrast in view, given the higher level of agricultural potential and marketing opportunities available:

> ESAP is about encouraging people to work hard to build wealth... removal of price controls and competition amongst businesses can be beneficial if it leads to reduced input prices and better producer prices, as is happening with cotton... ESAP means a more difficult life for farmers because input prices are rising faster than producer prices... (ibid)

In Ethiopia, the impacts of structural adjustment on fertilizer prices are only now starting to feed through to farmers, for whom fertilizer prices have risen significantly in real terms (Croppenstedt et al, 1998). For farmers in Wolayta, these changes have rendered even more inaccessible their access to purchased inputs which has been in steady regression since the closure of the WADU project in 1981 and the withdrawal of credit-based fertilizer support. In the last few years, the Ethiopian government has been strongly promoting and extending the fertilizer package developed with the SG-2000 programme. This may provide the possibility of accessing assured supplies of inorganic inputs at reasonable cost for better-off farmers with sufficient land and good market access. However the SG-2000 package raises serious concerns when spread to poorer farmers and drier, risk-prone areas.

In Mali, structural reforms were begun in the mid-1980s and included liberalization of cereal prices and the abolition of fertilizer credit schemes. Many farmers in the dry cereal-producing areas had never had easy access to such inputs since they were not in an area considered a priority for rural development interventions. However, farmers in Dilaba did have the opportunity to tap into project-supported credit and chemical fertilizers during the 1980s. For rice and cotton farmers, structural adjustment and devaluation of the CFA franc have had a much greater impact because of their engagement in market activities.

Devaluation of the CFA franc in 1994 has had a largely positive effect on farmers in Mali. Prior to 1994, cotton farmers were facing stagnant prices and rising input prices. The CMDT had limited processing capacity and had established a quota system to keep a ceiling on cotton production. The devaluation coincided with rising world market prices for cotton, such that very substantial benefits could be gained from expanding area under this crop. With the CMDT investing in new ginning capacity, and a lifting of quotas, the area under cotton has grown from 200,000ha in 1993 to nearly 500,000ha in 1996 (Jeune Afrique, 1998). While input levels in the first year after the devaluation were somewhat depressed, subsequently farmers re-established former practices. Thus, for example, average net returns per hectare of cotton rose by a factor of 3 to 5 over the period 1993–1996 (Giraudy and Niang, 1996). Prices have also risen for cereals, particularly maize, given high levels of demand from the neighbouring Ivory Coast. Not only the larger, better-equipped farmers, but also the poorer small-farm households have been able to take advantage of these opportunities and expand the area cultivated, gaining a substantial increase in income per hectare because of the large hike in cotton prices paid to farmers. In the irrigated rice zone of the Office du Niger, devaluation has also brought about increased demand for domestically produced rice, since imported Thai rice has become more expensive. As a result, farmers have seen a rise in returns averaging 10–35 per cent per hectare, despite an increase in input prices (Breman and Sissoko, 1998). Those farming households with livestock holdings have also done well following devaluation, given rising prices and increased demand from coastal West African states.

Structural adjustment has brought other changes to certain farming areas of Mali, particularly those covered by the CMDT and the Office du Niger. The Malian government has been required to privatize certain functions formerly carried out by these parastatal organizations, such as provision of veterinary services. The rapid withdrawal from veterinary service provision in 1995 led to heavy cattle losses from disease and damaging impacts on work oxen numbers in the CMDT zone. The CMDT has also been forced to become more transparent in terms of its pricing policy, and the share of cotton profits to be received by each of the three parties – farmers, the state and the CMDT. The programme to restructure the Office de Niger has brought changes in the responsibilities and rights of tenant farmers, providing improved security of tenure, and greater freedom over crop choice and where to market crops. Contract farming of certain vegetables (such as tomatoes for canning) is also now starting to develop in the irrigated lands of the Office du Niger, with traders providing access to credit, inputs, markets and technical advice.

Credit

Throughout sub-Saharan Africa, farmers have limited access to formal financial systems through which to gain access to credit and in which they can invest their savings. The establishment of such systems faces serious constraints which include low levels of income, poor infrastructure, high transaction costs and limited collateral with which to hedge against risks of default (de Groote, 1995). As a result, savings at village level are frequently held in the form of livestock, and farmers rely heavily on informal sources of credit from neighbours and family and earnings from migration and off-farm activities for purchase of equipment and farm inputs. In the research sites, systems to gain access to credit have been undergoing change as a result of structural adjustment and other measures.

Across the study sites, only in the CMDT area of southern Mali is such access more or less assured, though even here the CMDT has passed on responsibility for managing the loans to the National Agricultural Development Bank. In all other sites, while projects may occasionally set up and supply credit to a limited area, in most places farmers must rely increasingly on their own resources or on private sector loans, usually associated with cropping under contract to a commercial buyer. Thus, for example, for rice farmers in Mali, credit is no longer supplied by the Office du Niger, and farmers must rely on private sources with which to purchase inputs and equipment. In the southern Ethiopia research sites, most farmers rely on informal networks through which to gain access to loans. Bank credit is in very short supply and dominated by a few suppliers requiring significant collateral arrangements. Agricultural credit is otherwise limited to the extension programme which offers a fixed package of inputs on credit to farmers with strict systems for repayment. Poorer farmers are in particular difficulties as a result, having very limited networks for raising cash while being unable to make effective use of the credit package. As a result, rising levels of default and debt are affecting the poorer and more marginal farmers in the area. In Zimbabwe, formal credit was offered to all communal area farmers on reasonable terms in the 1980s through the Agricultural Finance Corporation. However, default levels, particularly in drought-prone areas such as Chivi, were very high and the facility has been withdrawn. Today, getting access to credit from government or private bank sources is increasingly difficult, in part because of the stringent conditions applied. Informal lending and savings arrangements are therefore the primary way by which farmers raise cash.

Rural infrastructure

Easy access to markets can provide a major spur to farmers to intensify agricultural production and investment in land improvement (Tiffen et al, 1994). Such effects stem from the impact of a broader array of demands for goods and services, and reduced transport costs bringing better margins on input and output prices.

In southern Ethiopia, the challenges set by the mountainous landscape to road building, combined with low levels of investment, have meant that rural infrastructure is poorly developed. However, since 1991, major improvements to the main road through the study area has brought shorter journey times and more assured access throughout the year. This has been particularly important for the lowland study site where, in the past, travel times to the main market town of Soddo were considerable. Today a greater range of motorized transport opportunities exist at much lower costs. Nevertheless, much transport to market continues to be done by foot and donkey, with people often trekking for many hours to reach a market. The profusion of markets, occurring on a daily basis (and sometimes with day, evening and even night markets), is a characteristic of the Ethiopian rural economy. Such markets give traders the opportunity to make small margins by selling and buying in different places. This source of off-farm income is particularly significant for women. With the increasing access, larger market centres such as Soddo have become more important, sometimes displacing smaller, local markets. This has a number of consequences. For those purchasing and selling goods, improved infrastructure has reduced transport costs with the result that both consumers and producers benefit. However, the reduction in trading opportunities in the smaller markets may have impacts on women's livelihood options, as it is often men, with access to cash, who can afford the transport costs to the larger market centres, with the result that trading activities become concentrated among those with capital assets.

In Mali, maintenance and improvement of the principal roads from Bamako to Sikasso, Segou and the north-east of the country takes up the major share of the roads budget, with very little done to improve feeder roads away from the main arteries. In the CMDT zone there is assured transport for the collection of cotton and delivery of inputs. For Tissana and Siguiné, the large market town of Niono is relatively close and provides many opportunities to diversify crops and income sources. Even in areas much further from markets, people often walk very considerable distances to market. But these distances limit the kind of crop which can be grown for sale, since it must withstand the heat and jolting during the journey, as well as increasing the time and costs involved.

In Zimbabwe in the 20 years since independence there have been major investments in road building, including roads within the communal areas, making transport and marketing considerably easier. There has been a resultant growth in bus and lorry traffic in the communal areas, with competition between operators driving prices down, although this effect has been offset to some extent by higher fuel costs stemming from currency devaluation. There are some differences in the level of rural road infrastructure between the study areas, with Mangwende being particularly well served with good connections to Harare and Marondera. Farmers regularly hire transport in groups for the transport of their produce. For vegetables in particular, timely delivery is key in order to gain the highest prices. In Chivi, the road networks have significantly improved in recent years. However, the distance to major market towns is larger than in Mangwende, with Masvingo being the most important. The road to South Africa which runs through Chivi provides important opportunities for trading both agricultural produce and other items. The tourist traffic along the road also provides a ready market for a range of produce, including craft items.

Research and extension services

Research and extension service provision has undergone major changes over the last decade in all three countries. In part this has been due to structural adjustment reforms which have reduced the expenditure levels in government services. But, in addition, there have been some other changes in focus, with a gradual realization of the need to gear research and extension support to the needs of small-scale farmers. In all three countries this has been a slow process, but through interaction with a range of project-based initiatives, both within and outside government, some changes are being seen in the broader national agricultural research and extension strategy in all three countries.

Since the 1970s, agricultural research and extension in Ethiopia has been associated with a technical package approach. A range of programmes have advocated different technical solutions to small-scale farming problems, but with relatively limited impact. While there has been important research, particularly on new varieties, this has had a limited impact on farming livelihoods in areas such as Wolayta. One criticism is that research has been largely focused on cereal crops for the highland areas. This is of clear national importance, but it has resulted in other agricultural production systems – including particularly the enset/root crop and pastoral systems of the south – being largely neglected. However, over the last few years the national research services have been undergoing signifcant reforms. With the formation of the new Ethiopian Agricultural Research Organization, a new and broader mandate for agricultural research has begun to be defined.

In terms of extension outreach, however, the focus remains on a package approach. This has been reinforced by the national adoption of the improved crop-fertilizer-credit package originally promoted by the NGO SG-2000. While there are undoubted benefits of the package under the right conditions, this does not suit everywhere and everyone. In Wolayta the previous experiences of the WADU programme during the 1970s provide an important lesson. When subsidized credit was available and the infrastructural, marketing and other requirements were covered by the project, significant gains were achieved in cereal production. However, this was at the expense of the traditional root-crop system, and when the project withdrew in the early 1980s, cereal yields collapsed and farmers had to return to a focus on their previous mixed strategy of combining enset with root crops and cereals. Not surprisingly, the impact of the government's agricultural extension strategy in the Ethiopia study areas has been mixed, with richer farmers in the higher rainfall areas being able to make good use of the package. However, poorer farmers by and large have not benefited and many, following poor rainfall years, have gone into debt (Carswell et al, 2000). The limitations of the approach, however, are now beginning to be recognized and a strategy for addressing the problems of poorer farmers in more marginal areas is being developed, with an extension of the range of extension packages to such issues as soil and water conservation and livestock management. The agricultural research sector in Mali largely consists of the Institut d'Economie Rurale (IER) which, despite its name, is mainly technical in focus. Agricultural research has paid greatest attention to the problems faced by cotton farmers in the CMDT area and irrigated rice producers in the Office du Niger. Recent structural reforms to the IER have led to cuts in funding and greater reliance on a range of clients, particularly donor agencies requiring short-term research support for their field projects. At the same time, IER has moved towards a regional model, with greater responsibilities allocated to the five regional research centres (of which Niono and Sikasso are part). At the regional level, consultation committees have been set up in the hope of establishing closer communication between researchers and farmer groups in that area. However, it is unclear how effective these have been in influencing the direction and methods followed by researchers. Rice and cotton farmers have thus received the lion's share of research expenditure. In both cases, this seems to have brought considerable improvements in yield when combined with favourable market conditions. Much greater attention is now being paid to differences between farm households in the CMDT region, so that the difficulties faced by small, poor households can also be addressed.

Rainfed cereal areas, by contrast, have not been the object of concerted research and extension work, with provision of technical advice and credit the result of limited-duration programmes such as the Programme National de Vulgarization

Agricole, or the presence of an NGO field project. Despite this neglect, farmers outside the main cash-crop zones have made very considerable changes to their cropping systems – taking up new varieties, adopting ox-drawn ploughs and experimenting with inorganic fertilizer – based on their own capacity to learn, experiment and share lessons. While earlier research focused on the development of technical packages for farmers based on inorganic fertilizer, much greater effort has been made in the CMDT area over the last ten years to promote more sustainable management of soils. This is being done by work on anti-erosion measures combined with better use of organic materials such as crop residues and manure. Private sources of extension advice and input supply are also growing, related to particular crops being cultivated under contract to a commercial buyer. Thus, for example, in the Office du Niger, irrigated tomatoes are being grown in the dry season for a canning factory, with seed, other inputs and advice being supplied to the farmers by the buyer.

In Zimbabwe, government policy towards agricultural research and extension switched from a concentration on the large-scale commercial farming sector to smallholders following independence in 1980. However, this transition has not been easy. The available technologies and the style of research which predominates in the Department of Research and Specialist Services (DRSS) of the Ministry of Agriculture has resulted in a relatively limited uptake of research results in the communal areas. This problem has been compounded by continuing budget cuts, particularly in the period following structural adjustment. This has limited the ability of station-based researchers to get to the field and interact with farmers. Nevertheless a number of project-based initiatives have in recent years started a more farmer-focused approach to agricultural research. The Farming Systems Research Unit (FSRU) in DRSS, for example, has developed a farmer-led participatory research approach in Chivi and Mangwende, with many experiments focused on soil-fertility issues. This has been complemented by more technical research both within DRSS and at the University of Zimbabwe supported by the Rockefeller Foundation-funded SoilFertNet. The result has been the exploration of a range of technologies and management practices which are more in line with farmer demands, and, in some instances, a quite rapid uptake of new practices.

In Zimbabwe, the links between research and extension have been relatively weak, except through more informal contacts at the local level. Agricultural extension, run by the Ministry of Agriculture department Agritex, has been hit by similar budget cuts as research. This has meant a decline in extension coverage over the 1990s, particularly as a result of reduced mobility due to mileage restrictions. In rethinking the role of extension in the country, a number of important lessons have been drawn from past experience. First, the top-down technology driven package approach which has dominated Zimbabwean extension support since the 1930s has been criticized as not really addressing farmer demands. Second, the high costs of broad field-level extension coverage (with the aim of having an extension worker in every ward) have been seen to be unfeasible given government budget limitations. In particular, the training-and-visit approach, originally recommended by the World Bank in the period following independence, has come in for a lot of criticism as being both too technically oriented and too costly. Drawing on a variety of experiments in alternative types of extension approach, particularly emanating from Masvingo Province (Hagmann et al, 1998), Agritex is now exploring more participatory approaches which redefine the role of the extension worker and the linkages between farmers, researchers and the extension system.

Land and tenure reform in the context of decentralization

Land tenure security is often seen as a critical factor in ensuring effective long-term investment in natural resources. A variety of land tenure reform initiatives have been started across the three country case studies. Various forms of land reform and resettlement have also been significant in affecting the distribution of land resources across the study areas. Land and tenure reform is occurring in the context of broader administrative changes associated with programmes of decentralization.

Farmers in Ethiopia have witnessed major upheavals due to land tenure changes and villagization, which have generated continued uncertainty over their landholdings. The land reform policy implemented by the Derg regime during the 1970s resulted in a major reallocation of land to farmers who were previously reliant only on tenancy arrangements with landlords under the feudal system. While this disrupted the strategies of richer landlords, it did provide new land for those previously unable to farm for themselves. However, despite the reforms significant inequalities in landholding persist, with former landlords often repurchasing or contracting land from poorer households. Today a huge range of landholding arrangements exist, including outright ownership, share cropping, contracting and different forms of tenancy. While many of these are notionally illegal, the range of informal institutional arrangements surrounding land are an important aspect of the local situation.

Resettlement policies to less densely populated areas in the lowlands have been important in Ethiopia since the late 1960s. For example, the lowland case study site was established as a settlement scheme in 1971 as part of the WADU integrated rural development project. The allocation of 5ha plots to former tenant farmers provided new opportunities for agricultural livelihoods, although the consequences of moving to a lowland area with different agroecological conditions and high levels of both human and livestock disease incidence caused many problems. During the 1980s, the policy of villagization caused further changes in landholding patterns. Villagization was aimed at rational planning for increased production, combining private and collective farming arrangements. The broader political effect was to increase the state's political and economic control over peasant farmers. Farmers in lowland areas of Wolayta were forced to move into villages and to leave behind the plots of higher-fertility *darkoa* land which they were in the process of enriching. Fortunately, they were to return to their home sites following the fall of the Derg in 1991 and reinvest in their garden areas. Resettlement and land reorganization have not been major features of land policy under the current government, with the land redistribution efforts in the Amhara region in the mid-1990s not being repeated elsewhere. Movement between sites instead tends to be more spontaneous, with families resettling to new areas (particularly in the low-lands) through informal connections with relatives and other contacts.

In Ethiopia there is continued debate at national level concerning further changes to land tenure (Dessalegn, 1994). The government insists that all rural land will remain the property of the state, but that this should not undermine security of land holdings and customary inheritance arrangements. However, given past government policies – particularly of land reform and villagization – many farmers remain sceptical about government intentions and a sense of uncertainty continues (Worku, 1998). Yet despite this, farmers continue to invest in long-term soil-fertility improvement in their garden sites, and the growth in on-farm tree planting in the area suggests that farmers are not thinking only for the short term (Carswell et al, 2000).

Regionalization, involving a form of political and administrative decentralization, has been a central plank of the post-1991 government's policy. While a process of devolving certain powers to the different regions which make up the country has occurred, it is unclear as yet how far this will lead to major changes in agricultural policy, given the continued political and administrative tensions between central government and ministries at the federal level and the new regional administrations, where capacity and political authority often remains weak. This is particularly apparent in the southern region which is made up of a wide range of disparate ethnic groupings (Young, 1996).

In Mali, the ongoing process of decentralization and land tenure reform provides an evolving landscape within which farmers must plan their strategies. Control over land currently being farmed seems relatively secure, with customary rules predominating (Lavigne Delville, 1999), but there is much greater uncertainty over management of collective resources such as grazing, woodlands and water (Joldersma et al, 1996; Hilhorst and Coulibaly, 1998). These common resources provide a variety of important products, including pasture for livestock which transport nutrients from bush to cropland. In addition, it is also not clear how the powers of the newly established rural communes will relate to customary structures at village level. While the tenure reforms (*Code domaniale et fonder*) propose allocating firmer rights to community groups to control access to resources within their territory, this may conflict with the claims that rural communes may wish to assert over resources now under their formal responsibility (IIED, 1999). Where communes see the allocation of rights as an important source of income and patronage, serious difficulties may arise over the prerogatives of village and commune-level structures. Given that the new *Communes Ruraux* were elected in May 1999 and are currently in the process of establishing themselves, it is too early to judge their likely impact. However, it should be remembered that the rationale for decentralization in Mali (and many other countries) has been based far more on service delivery and political considerations, rather than ensuring more effective management of land and natural resources.

In Zimbabwe, debate regarding land and resettlement has been underway since independence in 1980. After an initial flurry of activity in the early 1980s there has been little action on the ground until the last few years (Moyo, 1998). From the late 1990s, the issue gained greater attention from both government and donors, with a new phase of the resettlement programme approved in 1999. During 2000, however, the politics of land reform changed dramatically, as the ruling party and the 'war veterans' began to focus their electoral campaigning on the land issue. A range of land invasions followed, and an attempt by the government to institute a 'fast-track' resettlement policy. The degree to which such resettlement programmes will reduce land pressure in the existing communal areas, however, remains uncertain. Nevertheless a number of studies show that, if the appropriate support is given to new settlers and resettlement takes place in areas where productive agriculture is viable, then the potentials for a resurgence of smallholder agriculture in Zimbabwe are great. In practice, though, the consequences to date for farmers in the Chivi and Mangwende study areas have been minimal. Relatively few have been able to sign up for resettlement programmes, which have been targeted largely at richer farmers with Master Farmer Certificates. Instead, more informal processes of resettlement are occuring with farmers moving, particularly from dryland Chivi, to other parts of the country (notably Gokwe and the Zambezi valley area) where land is more abundant, and, more recently, nearby commercial farms have been invaded and occupied.

Parallel debates centred more on land tenure reform and decentralization are also ongoing. Following growing concerns about land tenure and rural administration issues in the communal areas, a commission of inquiry was established which suggested a range of changes to land administration and tenure issues (Government of Zimbabwe, 1994). The commission recommended that village areas be granted tenure rights on a collective basis, combined with a review of the village and ward committee system which was widely regarded as inadequate. A greater role for 'traditional' leaders and customary arrangements was argued for. However, the implementation of the recommendations has been fragmentary, with particular rural political contexts largely affecting change at the local level. With the political hiatus of the last few years, little progress has been made on the ground. Decentralization to Rural District Councils has also been seen as a route to more effective agricultural and land management in the communal areas, but, again, the capacities of district councils to do much without significant budgets and in the context of joint responsibilities with central line ministries has been very evident.

Policy Options and Strategies

A range of policy measures, therefore, is seen to affect farmer management of soil fertility. However, rarely has soil-fertility management itself been the main target of such policies. Rather, impacts on soil management tend to be the cumulative results of a series of interventions whose focus and interest lie in other fields. As Scherr (1998, p2) notes, 'policy makers typically consider soil quality not as a policy objective in itself, but as an input into achieving other policy objectives'.

The launch of the Soil-Fertility Initiative (SFI) by the World Bank, FAO and other donors was intended to remedy this weakness (World Bank, 1996). One objective of the SFI has been to identify more clearly those policies which are likely to have an impact on soil-fertility management, where overlaps and contradictions currentiy exist. National soil-fertility action plans are intended to promote greater coherence in policy making by bringing together those bodies with responsibilities which are likely to affect soils, and focusing on ways to encourage longer-term investment in improving soil quality. Thus, for example, the steering group for the elaboration of national plan of action to address soil-fertility management in Mali comprises representatives from the Ministries of Planning and Rural Development, as well as from the CMDT, the Office du Niger, the National Environmental Action Plan, the agricultural research sector, the World Bank and the Dutch Embassy.

It is important to examine both the content of policy (statements and instruments) as well as its process (elaboration, implementation and review) and to try and understand differences between what is said, and what actually happens (Keeley and Scoones, 1999; Mayers and Bass, 1999). It is clear that:

> The policy-making process is by no means the rational activity that it is so often held up to be... policy research over recent years suggest that it is actually rather messy, with outcomes occurring as a result of complicated political, social and institutional processes. (Juma and Clark, 1995, pp128–129)

Several points emerge from examining the policy process in the three countries studied. First, policy changes have stemmed largely from the demands of a range of international actors, rather than from internal debate and consultation among stakeholders at national and local levels. In many African countries, agenda-setting tends to be done within a very limited group of people, largely within government, with little or no public consultation, making it much more difficult to introduce alternative views and perspectives. The World Bank, IMF and major donors have also been able to maintain a highly influential role in policy directions because of the high level of indebtedness amongst many sub-Saharan African states, and their consequent dependence on development assistance. Governments remain heavily reliant on, and reactive to, new international initiatives (such as the Convention to Combat Desertification and the SFI), often in the hopes of gaining renewed funding rather than necessarily feeling committed to the objectives of the initiative in question.

Second, the data which drive such policy debates are heavily reliant on a very limited number of documents, which are repeated time and time again. These include the FAO survey of 1990 (Stoorvogel and Smaling, 1990) and research which attempts to put an economic estimate on soil-nutrient losses (Bishop and

Allen, 1989; van der Pol, 1992). Such data provide simplistic messages regarding the significance, diversity and dynamics of soil-nutrient management at farmer level, and also lead to a blinkered view of the means by which to encourage more sustainable agricultural practices generally. The end result is often a set of policy statements which bear only partial relation to what can be seen at farmer level, but which many are unwilling to contest.

Third, the current policy focus on soil-fertility management needs to be understood in the light of the structural adjustment measures undertaken by African countries under IMF and World Bank guidance in the 1980s and 1990s, which reduced substantially farmers' ability to gain access to inorganic nutrients by cutting subsidies and credit programmes. The fact that the World Bank is behind both structural adjustment and the SFI has sent a set of contradictory signals to African governments, who hope that the SFI may provide a vehicle for the reintroduction of such measures.

New directions? Recognizing the multiple dimensions of soil-fertility management

Interventions to address soil-fertility management need to consider five dimensions which frame the range of options available. First, as has been demonstrated throughout this book, the diversity of sites, soils and strategies found within and between African farming systems is very great. Thus, tailoring approaches to suit the opportunities and problems encountered in any particular location is of key importance. Second, there is a considerable level of differentiation between farmers in any one location, which means that no single package of measures will be appropriate for all. Third, as was clear from the discussion above, there is a wide choice of potential actions aimed at achieving better soil-fertility management, from direct technical inputs to broader macro-economic measures, which can be pursued either separately or in combination. This presents decision makers at different levels with a valuable menu of options from which to choose. The fourth dimension concerns the time frame over which such measures might usefully be implemented, given current conditions and other ongoing policy changes with an influence on soil management. Some measures produce rapid impacts, particularly those operating through prices and markets, while others are far slower in bringing about changes such as land tenure reforms, and changes to training of extension officers. The fifth dimension concerns the broader context, and how macro-level decisions might better take into account the need to promote more sustainable patterns of soil management at farm level. Hence the potential role to be played by a national strategy for soil-fertility management which forces an explicit analysis of how current policies in a range of fields affect incentives at farm level.

A sustainable livelihoods approach to policy design

So how can these multiple dimensions of soil-fertility management be combined? As the case study research has shown, an exclusive focus on the technical aspects of soil-fertility management is unlikely to generate effective interventions and appropriate policies. Soil-fertility management is but one part of a broader set of livelihood activities that rural people pursue. Taking a more holistic analysis, then, a sustainable rural livelihoods approach outlines the range of different 'capital' assets which such interventions might address, as discussed in Box 19.1. As can be seen, there are many routes to achieving the goal of improved soils management.

For each of the five forms of 'capital' described in Box 19.1, there will be a range of intervention options to be considered, depending on the assets and livelihood strategies of different groups of people, with men, women, younger people, older people, in-migrants and others requiring different forms of support. Thus, for example, ways of improving natural capital will need to consider how to address the particular constraints of poorer farmers with small fields and poor soils, who also have limited access to cash and labour. Thus, attention might usefully be paid to forms of micro-credit best suited to poorer groups, as well as getting extension staff to focus on the differentiated needs of farmers, instead of targeting the 'average' farm household. By contrast, the options open to better-off farmers in a given site are likely to be much broader and, therefore, prompt a different set of interventions.

Box 19.1 *Rural livelihoods: identifying avenues for intervention for soil-fertility management*

- *Natural capital*, through a range of direct interventions aimed at improving the biophysical status of soils, such as recapitalization, use of chemical inputs and build-up of organic matter, and construction of anti-erosion measures.
- *Financial capital*, by support to credit and savings schemes to facilitate the import of nutrients onto farms and investment in labour, transport, or livestock for their manure.
- *Physical capital*, by building roads and other means of communication to improve access to markets and thus shift relative prices and improve incentives for soil-fertility management.
- *Human capital*, through working with and building on farmers' knowledge and skills, to develop more effective partnerships between farmers, research and extension staff.
- *Social capital*, by improving the organizational capacity of farmers to work together, experiment with alternative technologies, reflect and evaluate options and identify needs from technical service agencies.

Source: Scoones and Toulmin, 1999

The way different social groups gain access to these different forms of 'capital' is dependent on a complex interaction of institutions and organizations operating at different levels. The institutional process which mediates access to such assets is therefore a critical component of any livelihoods analysis. For example, in Ethiopia, depending on social status, religious affiliation and the ability to pay in kind for labour, different people may gain access to labour for soil management and other agricultural activities through a variety of different local institutional forms. Such local institutions may interact with more formal organizational structures of the state or development agencies in various ways. Thus, for example, local, largely informal credit or savings organizations operating among networks of kin, friends or church members may be usefully enhanced by externally supported credit arrangements to improve the ability of members to increase financial capital. It is this interlocking, multilayered nature of informal and formal organizational arrangements which is central to an understanding of how livelihoods are constructed by different people in different settings. Insights into the changing nature of institutional configurations across levels, then, can assist with the sensitive design of appropriate interventions which enhance people's own capacities to manage resources.

Combining different approaches

Much of the current international debate on agriculture in Africa pays particular attention to direct interventions aimed at increasing soil nutrients, through supplementing natural capital by, for example, increasing use of inorganic fertilizer. However, there may be more effective means of achieving the objective of improving livelihood sustainability. Box 19.1 suggests other avenues which should also be considered in identifying a broader spread of options for tailoring to local conditions.

In any particular setting, it is unlikely that a single intervention, by itself, will make a big difference to soil-fertility management and improved livelihoods. For example, in agricultural systems where soil organic matter is in short supply, substantial inputs of N may be needed initially to generate sufficient biomass to contribute to the longer-term objective of improving soil structure and building organic matter content. At the same time, work could be initiated through farmer field schools and experimentation aimed at increasing human and social capital through raising skills, knowledge of more effective biomass management and strengthening partnerships between farmers and extension systems. At the macro-level, debate could be initiated on reforms to research and extension systems, ways of improving access to markets and credit, and strengthening of tenure security.

From the case study sites, a range of combined actions can be identified aimed at improving soil management and livelihood sustainability, which address the particular characteristics of location and farm household, as shown in Box 19.2 below.

From these examples based on the field research, a varied choice of interventions can be identified to support more effective soil-fertility management. Some of these are focused at farm and field level, while others relate to wider policy and macro-level changes. An analysis that cuts across scales – from the micro to the macro – and across intervention areas – from technical to institutional – is essential if the appropriate mix is to be found. As we have seen, however, much of emphasis in the past – and persisting to the present – has focused on technical options derived from a limited view of soil management emanating from soil and agronomic studies. The emphasis on inorganic chemical fertilizers is perhaps the dominant example of such an approach, although it could be argued that the low external input and organic farming perspective suffers from a similar weakness and narrowness of vision.

Any technical options, then, need to be seen in a broader context. This points to the importance of a wider socioeconomic and institutional analysis, asking who gains and who loses from different options? How are different intervention options linked into broader patterns of livelihood change? Which combination of institutional and policy factors operate and interact at different levels, and how do they help direct farmers along more desirable pathways of change?

Strategies for Integrated Soil-fertility Management: Following a Phased Approach

As previous sections have shown, a long-term strategy for integrated soil-fertility management needs to take account of a wide range of factors, from the macro to the micro, and across a huge range of policy areas. Such a strategy needs to consider how to implement such a range of measures over time, and best link local-level practice and national level policy. This would allow for the design of a set of interventions to be implemented, which are tailored to particular settings and able to adapt to changing circumstances.[3] A phased strategy would therefore need to start with a period of participatory planning and assessment, the development of new skills, and be linked to a series of decisions regarding the appropriate scale and vehicle for intervention.

A first step would be an initial *assessment of context and constraints* to identify the biophysical, socioeconomic and institutional characteristics of the district, province or commune where work is planned. In parallel, a macro-level analysis is needed of policies which affect the pattern of incentives for farmers to manage their soils more sustainably, given the range of other opportunities and constraints they face, in the agricultural sector and elsewhere. At farm and community levels, *participatory planning and analysis* enables local people, researchers and extension staff to identify a set of activities which farmers want to try, and to establish methods for joint reflection and evaluation. Experience with participatory extension approaches in combination with farmer field schools provides a variety of practical tools for supporting farmers in the analysis of problems, choice of options to test

Box 19.2 *Identifying options for policy and practice: examples from the field sites*

Mali

In the irrigated rice village of Tissana in Mali, the diversification by farmers into crops other than rice is set to continue. Further growth of the scheme is also underway, with investment in construction of new canals and irrigation works into neighbouring dryland areas. Interventions to improve soil-fertility management within the Office du Niger thus need to include a combination of:

- A shift in research and extension from an exclusive focus on irrigated rice, grown with inorganic fertilizer, towards support for other crops, combining organic and chemical materials to best effect.
- Work with newly settled rice farmers who are less familiar with inputs and credit, water management and marketing, as well as how best to maintain and improve the quality of soil on their plots, combined with attention to areas long under cultivation where soils are suffering from salinization and loss of structure.
- Seeking maximum complementation between livestock and cropping enterprises in and around the Office du Niger. Cattle herds depend on gaining access to dry-season grazing, while at the same time providing manure which is becoming a key component of the farming system.

Ethiopia

In the highland site in southern Ethiopia, livelihood options are increasingly constrained. Limited land areas and the lack of available oxen and cash to invest in increasing agricultural production on the small plots of land means that a flexible strategy involving a range of farm and non-farm activities is essential. The current focus for rural development in this area concentrates on an extension package involving improved seeds and fertilizer linked to a credit arrangement, which is implemented in an inflexible manner. Only the better-off can risk the package and gain the undoubted benefits. By contrast, this option increases vulnerability for poorer farmers, as they have no other sources of income or land to fall back on in case of failure. Alternative options could include:

- A wider set of technical options as part of the package, which involve lower-risk crops and management practices.
- A more flexible form of package so that farmers may take different elements of the package in relation to the condition of their soils, their production objectives, their asset status and risk preferences.
- An alternative form of 'credit for livelihoods' which would allow the allocation of credit to a range of livelihood activities to encourage agricultural improvement in the context of wider livelihood diversification.
- The linking of formal credit (from government and private sources) to informal institutions governing savings and mutual assurance.

Zimbabwe

In Zimbabwe, the increasingly uneconomic option of applying inorganic fertilizer at recommended rates has resulted in declining use, even in higher-potential areas where agronomic responses are relatively good. This has potentially negative impacts on the viability of agriculture in these areas, with consequences for economic growth and food security. Farmers' own experiments with combinations of organic and inorganic amendments have not received much attention from research and are not recognized in standard extension support. A range of options for improving the situation suggest themselves.

- A revision of fertilizer recommendations to take greater account of local agro-ecological setting and socioeconomic circumstance, with a set of graded options with different mixes offered by local traders.
- Support for new fertilizer traders and suppliers to encourage a growth in the market. A variety of public–private partnerships could be explored which might help reduce trading margins, particularly in more remote areas, and so reduce farm-gate costs.
- Different bagging options and more variety in fertilizer mixes, with advice offered by retailers, would allow greater customer choice, and perhaps greater demand, particularly from those requiring relatively small amounts for specific uses.
- More emphasis in research and extension on improving fertilizer-use efficiency through different placement and timing options. Combined with innovative ways of combining inorganic with organic sources, limited supplies of fertility inputs could be made to go further, thus increasing productivity.

out, and strengthening of organizational links to help spread ideas and discussion amongst farmers. At the same time, *an assessment of organizational setting* is needed to identify the current strengths and capacity of different channels through which a combination of interventions might be supported. This will depend on existing structures within the existing governmental, NGO and private sectors, the skills and resources available, and the flexibility and openness of different structures to working with farmers in a more intensive and collegiate manner.

As already discussed, the tailoring of soil-fertility interventions to the diversity and dynamics of particular contexts will need to go beyond a purely technical focus, to embrace a much wider set of options (see Boxes 19.1 and 19.2). The skills needed by research, extension and development agents to take forward the approach outlined above will need to include:

- Economic and social analysis to understand the diverse constraints faced by farmers and the historical dimension to the farming system's development, in order to set the particular issue of soil-fertility management within the broader context of farming livelihoods.

- Participatory planning, analysis and facilitation of farmer-led experimentation, by support to processes of learning and exchange, and major changes in the roles of research and extension staff. Such changes are partly underway in many research and extension structures but require further commitment to ensure their firmer establishment, and the integration of participatory approaches within the way such organizations operate.
- Institutional and organizational analysis to identify structures with which to work and pathways along which the goal of improved soil-fertility management can be achieved. For example, in Mali and Zimbabwe there is a much greater role now being played by the private sector (traders, transporters, shopkeepers) in the provision of inputs and purchase of crops. Organizational analysis needs to assess, for example, how best to build on the energy and flexibility afforded by the local private sector to improve access to inputs and markets.

However, it takes a long time to change the ethos and skills base available to institutions such as government research and extension agencies. Hence, a long-term programme for training and retraining may be required, as well as reliance in the short term on other sources of expertise, such as the NGO community.

Developing a strategy for integrated soil-fertility management will also mean making choices about level and strategy. Trade-offs and synergies must be assessed between the following strategies:

- *A local-level focus*, based on a participatory learning approach which gradually builds capacity at this level through the development of skills, pilot projects to test out methods of working with farmers, training of trainers and methods of spreading experience with possible partners. There may already exist a body of organizations with considerable experience in this field on which to build. Even if lacking within a given country, there may be useful experience in neighbouring countries on whose skills such a locally focused programme could be based. Support to networking amongst the various organizations working on participatory soil-fertility management could be one among several ways of spreading such approaches, through exchange of experience and lesson learning. Attention must also be paid to structures of incentives faced by researchers and extension agents to adopt new methods of work, other changes underway in the agricultural research and NGO worlds, the space for local fora to be established and opportunities for linking debate at local level with higher levels.
- *A centralized approach with a technical focus*, such as distribution of rock phosphate supplies for recapitalization of soils. This would require a well-planned system for organization of delivery, instructions to farmers regarding its use and methods for recouping costs. The newly completed National Strategy for Soil-fertility Management for Burkina Faso provides an example of such a technical focus involving the distribution of substantial volumes of rock phosphate mined in the north of the country to farmers in the centre and

north-west (Government of Burkina Faso, 1999). The cost of this activity, estimated to be 5.9 billion CFA francs (equivalent to US$9.7 million), may well be covered from a range of interested donors who often find it easier to provide a single large payment of funds than a smaller, regular commitment.

- *A macro-policy focus*, which aims to influence policy measures in ways likely to improve the incentives faced by smallholder farmers. Such a macro-level focus requires that farmers be sufficiently well-integrated into economic and policy circuits for changes at macro-level to have an impact at farm level. This is much more assured where farmers are already engaged in cash-crop production and reliant on significant levels of purchased inputs. In such cases, price changes for inputs and outputs can have a major and rapid impact on choice of crop, and the level and type of soil-fertility inputs used. In other areas more distant from markets, pricing policy will have more muted effects. Use of macro-level instruments also assumes a willingness in government policy and donor circles to develop a more coherent approach to addressing soil-fertility management for improved livelihoods. Without such coherence, the incentives faced by farmers are, in practice, merely the net result of decisions made in a number of areas with no explicit account taken of their impact on soil management.

As part of any consideration of phasing external support, it may be appropriate to look at how such approaches may be combined at different points. It may, for instance, be essential to address broader macro-policy issues before embarking on a local-level approach, as without such an enabling context at higher level, local initiatives may fail. Equally, it may be appropriate to aim for a top-down, technical intervention (such as fertilizer supply) to address the immediate consequences of short-term food insecurity and build towards a more long-term integrated and participatory approach over some years.

Future Directions?

The approach outlined above contrasts in some important respects with the current round of environmental strategies and conventions which are in the process of preparation and implementation. These include the UN Convention to Combat Desertification, the Soil-fertility Initiative and National Environment Action Plans. One obvious problem raised by these environmental strategies is the degree of overlap, duplication and waste involved in pursing often similar objectives but through different structures, which actively compete with each other, both at national and international level. A second issue concerns the very high cost of preparing such global strategies in comparison with the funding available to implement what has been agreed. For example, it is reckoned that the cost of negotiating the UN Convention to Combat Desertification must far exceed US$100 million over the period from May 1993 (Toulmin, 1997). It is reasonable to ask whether such sums are justifiable given the end product and the likelihood of the intended beneficiaries gaining anything tangible from the National Action Programmes currently being formulated. But the third, and most important, problem concerns the approach taken by these international plans and strategies. Despite a rhetorical flourish in favour of participation and consultation, and a nod in recognition of diversity, such initiatives continue to be led by international donors, and emphasize the important role of international coordination and facilitation, rather than taking measures to ensure real interest and ownership in the countries concerned.

It is vital to have an agreed consensus regarding the nature of the policy problem being faced, and the system of which it forms part. The 'crisis narrative' expressed in many international statements about the state of African agriculture tells a particular story which is appealing in its simplicity. It suggests that things are bad and getting worse, and something must be done urgently. While this may be good at raising the interest of donors and others, it may result in poorly thought-out and hastily implemented projects which make it difficult for other more considered approaches to be carried out. Such interventions may, in some cases, undermine livelihoods and reduce the potential for sustainability in the long term. Programmes which stress inorganic fertilizer use may, for example, push out a more balanced approach including biomass management which would help assure the longer-term structure and productivity of soils.

An alternative, more cautious way forward is needed. Such an approach does not state that 'there is no soil-fertility problem', but rather that problems are local, specific, differentiated and dynamic and will require mostly local efforts to be addressed effectively. This approach proceeds through a combination of farmer experimentation, monitoring and sequential learning as part of a longer-term participatory process. It is less glamorous than global initiatives and spends aid money less on technical aspects and more on building local skills and reforming institutional and policy processes. Such an approach pays particular attention to the phasing and skills required for pursuing this kind of programme, it acknowledges the very diverse set of conditions and practices found at farm level, and it recognizes that African farmers have been very creative in their ability to adapt and cope with rapid changes to the economic, institutional, technical and political settings in which they find themselves. While such an approach focuses on the local and the particular, it recognizes the importance of the broader macro conditions within which local practices are set.

Those in favour of this approach need to establish a rather different kind of debate at global level which avoids simplification. The narrative for such an approach tells a story of diversity and dynamics and the need to support a set of locally generated processes, pay attention to institutional and policy settings and place soil-fertility management issues in their broader livelihood context. It is hoped that this book can make a contribution to this alternative vision and so help set the debate on how best to support soil management in Africa on a new and more productive path.

Notes

1 It is beyond the scope of this chapter to review these in detail, but many other studies provide useful overviews. For example, Bumb and Baanante (1996) and Larson (1993) on fertilizer use; Lal (1984) on soil conservation; Greenland and Nye (1959) on fallows; Vogel (1994) on tillage; Mugwira and Murwira (1997) on animal manures; Giller and Cadisch (1995) on nitrogen fixation and Jones et al (1997) on legume residue use.

2 For example in Zimbabwe, 10 tons of manure per hectare every three years is the standard recommendation.

3 See Defoer and Budelman (2000) for a set of practical guidelines about how to develop an integrated soil-fertility management approach at farm level over a series of cropping seasons.

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20

Social Visions of Future Sustainable Societies

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All manner of social issues receive short shrift in the debates on 'environment and development' and 'managing the global commons'. Family life, community, stratification and individual dignity and fulfilment all suffer from varying degrees of neglect, while international security, nature/society relations, economic alternatives and processes of social change are badly in need of new theories. To the extent that the discussion is couched in terms of sustainability, the emphasis has been on reconciling ecological sustainability (planetary life support) with economic sustainability (continued economic growth), while social sustainability (creation of conditions for community and individual well-being) is generally ignored – or equated with economics, which is almost as bad. Social sustainability, we should note at the outset, does not mean the continuation of existing social structures but, rather, creation and maintenance of the conditions for creativity, empowerment, self-determination and self-actualization.

Research, both past and present, reflects this imbalance. For example, in a 1989 World Future Society publication, most of the items absent from a list of issues deemed important by a panel of 17 prominent American futurists are social in nature (Coates and Jarratt, 1989, pp24–25). Current research shows little change: for example, global environmental change is widely construed as a serious global problem with human causes (ICSU, 1987; IFIAS, 1987; IGES, 1999; ISSC, 1989; Jacobson and Price, 1991), yet the International Human Dimensions Programme has a tiny budget compared with the science-based International Biosphere-Geosphere Programme, a dichotomy largely apparent in the national global change research programmes. In general, little funding is available for collaborative, international, long-term social science research, and the funding allocated to policy work is usually for specific policy problems rather than for understanding more broadly human-induced environmental

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change. The assessments by the American Council for the United Nations University (ACUNU) in the Millennium Project (Glenn and Gordon, 1999; *State of the Future*, 1997, 1998, 1999) show important gaps to be filled.

This hesitation to engage social issues is perhaps understandable – ecology and economy alone are complicated enough (Daly, 1999); the social and political aspects, as emphasized throughout this volume, are often regarded as intractable and politically touchy; however, the price of ignoring them is high. Social issues are central to problems of environment and development, and are, in any case, worthy of attention in their own right.

Social concerns are critical to environment and development issues in several ways. First, a number of authors, working on an array of environmental-degradation problems, have argued that these issues are fundamentally social in nature. For example, a 'downward spiral' linking poverty and environment is widely recognized (e.g. Durning, 1989; Kates, 2000; Kates and Haarmann, 1992; Leonard, 1989; Mellor, 1988); Blaikie (1985), Blaikie and Brookfield (1987), and Blaikie et al (1994) argue that land degradation is a social problem, related to a 'simple reproduction squeeze' (e.g. Bernstein, 1979). Hunger can be viewed as a distribution rather than a production problem (e.g. Lappé and Collins, 1978; Lappé et al, 1998), as an entitlement problem (Sen, 1981), or as an outcome of political conflicts (Chen, 1990); a few decades ago, it was viewed as a population-control problem (e.g. Ehrlich, 1968). To the extent that any of these observations are accurate, social as well as economic and environmental factors will determine whether clashes of environment and economy can be resolved.

Second, leaving aside momentarily the thorny problem of implementation, if policy makers do attempt directly to reconcile environment and economy, they still face the task of anticipating or identifying institutions, political structures, value systems and lifestyles that are consistent with the desired or necessary conditions. What kinds of social structures, belief systems, families, activity patterns, geographies and aspirations will be compatible with the environment/economy system they recommend?

It is clear that merely making and attempting to implement policy does not necessarily result in actual social change, particularly given the tendency of the policy makers to take existing social structures and institutions for granted. Any changes in resource use, in the structure of the economy or in nature/society relations must all be implemented through the existing social system and will require major changes in that system. Relatively little is really known, however, about the sources and dynamics of social change, and even less under such conditions as global scale of impacts, rapid change, large populations, complex technologies, diverse and interacting cultures, and responses to subtle and systemic problems with long lag times. It is clear that societal initiatives or responses that work in some cultures do not work in others.

These three concerns – global change as a social phenomenon, identification of social systems compatible with ecological and economic sustainability and the dynamics of social change – all point to the need for an integral social science engagement in any discussions of sustainable futures. Furthermore, it is clear that the talents of the entire spectrum of human knowledge and creativity – including all the social sciences and the humanities – are needed to address these issues. Discussion and reflection on the social implications at all scales of current trajectories and possible alternatives are sorely needed. The two overriding issues of where to go and how to get there, defined in social terms, need concerted and determined attention.

To return to the role of planning in the context of ecological and economic reconciliation, although there is an argument that responsible public policy must try to manage key environmental dimensions, planning alone is not enough. Furthermore, it cannot be done in a social vacuum: neither rational environmental policy nor planned economic growth necessarily guarantees fundamental human rights such as livelihood security, freedom, dignity or opportunity; nor do they result in the maintenance of human values, cultures or communities; nor do they enhance human welfare, particularly for marginal or exploited groups. Securing such values must be a principal motive behind whatever planning does occur, and therefore cannot be the prerogative of current planners. The full plurality and diversity of values that exist in society must be mobilized to inform and guide policy making.

This leads to a second (and much more critical) point – that social goals and considerations are, a priori, pre-eminent. After all, fulfilment of basic needs propels human material interactions with the rest of the planet: the entire economic system is supposed to be motivated by the enhancement of human welfare. And then there are the broader dimensions of individual and community experience to which people attach great importance – values and aspirations; our relations to each other and to nature; the need for meaning and fulfilment; the institutions through which we interrelate; avenues for creative expression; meanings, symbols, belief systems; in short, family, culture, religion, work, play, artefacts.

Even if global economic planners and managers do devise an efficient, sustainable way to reconcile economic growth and ecological limits, what would that world be like and would anyone want to live in it? In addressing the future, it is equally possible to make a desirable, livable world the starting point, and to strive for resource use and economic systems that foster the attainment of that future. Do we eschew such an approach because of an assumption that everyone wants to live like upper-middle-class North Americans or Europeans, but cannot, owing to resource limits and economic problems? If so, this is surely an assumption worth examining. Gandhi's famous statement, reported by Tolba (1987), may be relevant here: when asked if independent India should be like Britain, he asked, 'If it took Britain half the resources of the world to be what it is today, how many worlds would India need?'

It is a question of priorities. Social systems should not be forced to evolve from determinations of optimal capital, material and energy flows; rather, economic and material systems should be designed to support social ideals. Stating the same point differently, one can argue that it is no more 'unrealistic' to expect the economic system to adjust to human needs and ecological limits than it is to expect people to change in order to serve economic imperatives or to expect nature to continue to conform to economic demands.

Not that those are the only options, or even that the global capacity to design and implement ways for reaching solutions is well developed. There is little reason to suppose that change really occurs in this way – by top-down management – no matter what the priorities are. At the very least, this exploration needs to be interactive, so that thinking about the future environment and economy is continually tested against thinking about societal and spiritual aspirations. If the direction and weight of current discussion fail to match real priorities, this should be acknowledged and corrected.

Visions and a History of the Future

If the preceding line of reasoning has merit, the envisioning of alternative futures is an urgent priority. Although 'the concept of alternative futures has become the linchpin of current future thinking' (Coates, 1989, p16), much of modern futurist thought has exhibited a very limited conception of alternative futures.

Modern, formal futurism has a relatively short history. Modernists tend to assume that, until very recently, basic survival was an all-consuming endeavour, leaving little time for idle speculations, and that past societies were relatively unchanging and people expected the future to resemble the present and the past. A sense of human influence over one's own destiny grew from the late Middle Ages onward (Polak, 1961, pp1, 33), however, until the positivists, religious and secular repression kept most Western minds fixed firmly on the past and the present (Adelson, 1989). The rapid technological advances of the industrial revolution, along with social changes brought by capitalism and by the revolutions of the late 18th century, raised obvious questions about the future of society (McHale, 1969), while Darwin and the geologists were expanding the magnitude of conceivable timescales (Alkon, 1987). The idea of constant social and material change has been slowly penetrating popular and official culture since the 1840s. It has influenced American government planning since World War I, as it influenced the Soviet Plans of the 1920s and 1930s (McHale, 1969). Forecasting came of age in World War II in the United States, leading to the development of a formal 'science' of futurism.

In his *The Image of the Future*, Polak (1961) warned depressed, post-war Europe of the danger of living with no mental horizons beyond the present and of the need to envision alternate futures. Despite this broad view, modern futurism concentrated on narrow post-war military and corporate concerns such as strategic planning, R&D and marketing (Coates, 1989; Coates and Jarratt, 1989). Governments and corporations, whose ability to pay and high stakes made them easy clients, became the main constituencies (Adelson, 1989). In response to this narrow base of clients, formal futurism has largely abandoned imagery and social imagination and has embraced the technologies of social forecasting and cross-impact analysis. As Elise Boulding (1983) puts it: 'Polak asked for visions. Futurists give blueprints.' We return to some of these issues below.

Despite its substantial shortcomings, formal futurism points to the importance of envisioning alternative futures. 'Visions' may be defined as stories of possible alternative futures (Anderberg, 1989; Nagpal and Foltz, 1995; Stokke et al, 1991). The process of forming them may be viewed as a purposeful strategic choice, as a tactic for moral suasion, or as an innate propensity of the human psyche.

The first posture is exemplified by Gordon (1989, p26), who states that 'without thinking about the future, we abandon our destinies to chance and the decisions of others'. Simmonds (1989) shares this view, arguing that, in order for institutions to get where they want to go, they must have a sense of where they are going and an ability to institutionalize problem solving. This is, perhaps, the inspiration behind the global modelling efforts of the 1970s (see below) and the various scenario-development and integrated-assessment efforts of the 1980s and 1990s (Morgan and Dowlatabadi, 1996; Rotmans and Dowlatabadi, 1998; Timmerman and Munn, 1997; Toth, 1995). Giddens takes a broader approach, denying that humans are condemned to be swept along by inevitable social forces and calling for the exercise of sociological imagination – being 'conscious of the alternative futures potentially open to us' (Giddens, 1987, p22).

The second position generally appears in the context of empowering a specific social movement or project. Caldwell (1985, 1990), for example, adopts it in reference to environmental politics, arguing that scientific knowledge alone is ineffective in changing behaviour, because it provide[s] no comprehensive view of the future – or a route-map to reach it – that most people find plausible and persuasive. Rather, scientific knowledge must be converted into 'a vision of the possible', to be realized through a programme of action that enlists belief, a popular, political movement with 'a vision of the possible that possesses a quasi-religious quality' (Caldwell, 1985, pp195–196). Similarly, Malone (1988, p289) calls for 'unleash[ing] the creative power of human reason' to develop alternatives to nuclear annihilation and planetary environmental collapse; this may be 'an unrealistic dream … but surely at least a vision – and from Proverbs we know "Where there is no vision, the people perish"'.

The third position is an essentialist one, held by many futurists. The claim is that each person carries around a view of the world, built from everyday observation and interpretation, that is projected into the future (e.g. Stokke et al, 1991). According to Adelson (1989, p28), implicit 'images of futures within which … intentions take shape and make sense' are an inherent part of the human psyche which help form our view of the present and are necessary to purposive action. Therefore, neither individual nor group behaviour, culture nor politics can be entirely understood without understanding those images. A better understanding of human behaviour, and particularly its purposive aspects, entails dealing with the key role that images of futures play in shaping it (Adelson, 1989, p33). These images also have a pragmatic role, since they are essential to the ability of individuals, organizations or communities to compose actions, strategies and policies; to fit them into their context; and to give them meaning (Adelson, 1989, p32).

Similarly, Elise Boulding (1983) argues that, from the individual to the societal level, images about 'the not-yet' are constantly generated. This imagery inspires our intentions as we move toward that which we consider desirable. Innate human creativity allows the imaging of alternatives to the present. Despite repression of these images through social stress and socialization processes (such as education), 'all folk experiment with new ways of seeing and doing. The mental imagery precedes the overt act. If this is normal human activity, then utopia-building, in the broadest sense of the word, is a normal human activity' (Boulding, 1983).

Taken together, these conceptions of social visions – empowering, inspirational/manipulative or universalistic – argue for the necessity and power of visions. Polak, taking a mixed idealist/materialist view of history, claims that such images play an active historical role. He argues that forming images of the future requires an awareness of the future, which makes possible a conscious, voluntary and responsible choice among alternatives. These images are constantly reformulated in a dialectical process between the image itself and the actuality of an unfolding future (Polak, 1961, pp1, 41–42).

At minimum, it is clear that some people see a need for overall social visions to guide action – whether that vision is articulated as an artistic creation, a corporate plan or an ideal to guide policy deliberations. Such an enterprise has often been viewed as socially ambiguous. Modern futurism, although 'more respectable than it used to be' (Gordon, 1989, p21), is tainted by the shady aspects of other futuristic enterprises. Futurism gets a bad name from 'mediums and hallucinogens and yuppie stockbrokers … turn[ing] over tarot cards and pork bellies' (Adelson, 1989, p28).

Serious rejection of the value of envisaging societal futures may be found in other quarters. There are some who, except for relatively narrow endeavours such as military or industrial strategic planning and technology assessment (Coates, 1989), see no need for visions, finding in technological optimism and progress a belief that things are already fine or getting better. Among the scientifically orthodox, any endeavour so explicitly dependent on imagination is automatically suspect. Among others, a distrust of unscientific, non-material and (possibly) elitist idealism has lingered since Marx's day. An emphasis on historical specificity and dynamic process rather than static end point, and a claim that the future is unimaginable because it is impossible for those conditioned by present social conditions to conceive of that which will be produced by human beings not yet born acting under new conditions, have engendered disinterest or suspicion about whether the project of envisioning futures merits human struggle.

Despite these views, it is essential to ponder goals and directions. Creating multiple visions – confronting a diversity of goals, values and structures – allows for ongoing clarification, communication, contestation and critique of alternate futures (Nagpal and Foltz, 1995). It also provides a forum for examining possible ramifications of current decisions, envisioned actions and proposed new pathways.

Broadening the discourse

Incorporating social visions into the discourse about the future would serve the purpose of explicitly introducing a number of ignored or neglected elements into the 'managing the planet' discusssion. In the process, it would also open up that discussion to critique and to much wider participation.

Futurists and their clients have been accused of being motivated by goals of control and manipulation (e.g. Dublin, 1991); however, a number of more benign interests – such as concern for children and grandchildren, seeking information on future impacts in order to guide current actions, simple nosiness or curiosity – may also motivate the desire to know the future. Some of us want to know what life will be like after us, and how our time here affects what follows. For others, a deep spiritual connection with the Earth and its creatures, religious or ethical notions of stewardship, or a strong sense of responsibility for the Earth and its future, inspire concern. Still others harbour a deep respect for what has come before – a sense of history. All of these motives reflect a common desire to know what it would be like to live in various possible futures.

Whereas such issues as population, energy, food, pollution and the like do tell us something about the constraints under which society is organized, they shed little light on the nature of lived human experience. Just as today's statistics on coal mining, methane emissions or capital flows fail to capture the experience of most peoples' lives, future scenarios limited to such factors constrain human inquiry, when we should be seeking to liberate and expand it. Whereas some specialists enter the futures discussion in such topics as material flows, atmospheric gases, capital investment, species richness, energy-conversion technologies, agricultural production or demographic profiles, and their results are a needed part of knowledge, such analyses are intrinsically unable to explore the nature of society and the human condition. How people will live, and how all these phenomena will be translated through societal institutions into factors affecting daily life and human dignity, remains opaque and unexplored. Understanding what some future circumstance might feel like not only provides empathy or human interest but also makes possible a holistic view, a demonstration of interconnections.

Thus, 'dispassionate' social science is not the only, or even the most, valid element in the current discourse. In academic terms, a 'passionate' social science and a stronger voice for the humanities are needed. Finding diverse, rich and textured ways of expressing social visions – through literary or artistic means, for instance – can make the issues accessible to more people and can contribute to emancipatory assessment, humanistic orientation and democratic decision processes. The expansion of discourse into the areas of everyday life, tapping our concerns about our grandchildren and about the impacts of our present lives – and piquing our curiosity – can open the possibility of capturing and mobilizing popular attention to important issues, perhaps even enabling the Habermasian dialogue advocated by O'Riordan and Timmerman in chapter 14 of *Global Environmental Risk* (Earthscan, 2001).

Confronting modellers with issues derived from inquiry outside their bounds of analysis, propelling social choices and social possibilities onto the public agenda, and stimulating explicit thinking about alternative futures can all generate a more powerful knowledge as well as greater awareness of the consequences of present decisions and policies (or of passive acquiescence to them). Public dialogue, conducted through alternate social visions, may also help to clarify the fact that no particular technical, economic or environmental scenario is inevitable; that a particular set of variables or trajectories does not necessarily translate into a specific social scenario; and that futures (and risks) must be negotiated. Choice, not determinism, prevails. Viewed in this way, thinking about the future can have an empowering rather than a discouraging effect, and can form an important part of emancipatory global risk analysis.

We have asserted that social concerns have been inadequately addressed in past research attempts at envisioning the future. The outstanding efforts of this type were the global models generated in the 1970s. To test this assertion, we turn our attention to an examination of the social content of this first generation of global models.

Global Models, Futurism and Social Visions

Looking at global models

A number of comprehensive efforts to predict the planetary future were mounted in the 1970s. Several factors spurred this work. Mounting concern over population, pollution and food supplies was expressed in an awakening environmental movement and in such books as Rachel Carson's *Silent Spring* (Carson, 1962), Paul Ehrlich's *The Population Bomb* (Ehrlich, 1968), Barry Commoner's *The Closing Circle* (Commoner, 1971) and E. F. Schumacher's *Small is Beautiful* (Schumacher, 1973). The use of the image 'spaceship Earth' by Kenneth Boulding (Boulding, 1973) and Buckminster Fuller (Fuller, 1969) acquired new power, owing to photographs of Earth taken from space and the moon. Developing computer technologies made possible the manipulation of large quantities of data about the present in the service of constructing plausible futures.

Multiple global models appeared. Their distinguishing features included a global scale; a methodology based on extrapolation from the present; and a focus on the interactions among population, environment and economy. These models and their constituent features have largely defined the terms of the mainstream global environmental debate up to the current time. The emphasis has been on demography, resources, pollution and capital. Social commentary proliferated in the 1950s and 1960s (e.g. Bell, 1973; Fromm, 1955; Galbraith, 1958; Heilbroner, 1972; Marcuse, 1964; Riesman, 1950; Whyte, 1956), including reports on global futures from the likes of the Commission on the Year 2000 (AAAS, 1965–1967;

Bell, 1969) and the International Peace Research Institute (Jungk and Galtung, 1969), and reports addressing the specific issues taken up by modellers [e.g. MIT's Study of Critical Environmental Problems (SCEP, 1971) and the Ward and Dubos (1972) report for the 1972 UN Conference on the Human Environment in Stockholm] – yet the models, not the rich variety of research, were adopted as the defining voice of global environment and development issues. The discussion that follows centres on the models, partly because a new generation of global models is now being created [e.g. the various efforts at integrated assessment; the PoleStar project of the Stockholm Environment Institute, reported in Raskin et al (1998); and the Hammond (1998) analysis of the 21st-century scenarios].

In the early 1990s, Gordon Goodman, Director of the Stockholm Environment Institute, discussed with members of a Clark University group his plans for PoleStar, an analytic process for systematically exploring alternative futures to inform international efforts for coping with global environmental change. The centrepiece of this process as it has developed is an accounting device – the PoleStar computer-based tool, building upon the first generations of global models – that allows an ongoing exploration of global environmental change. The Clark group argued that a process such as PoleStar should include a component missing from the earlier modelling efforts – an explicit exploration of the social nature of future sustainable societies. Such an inquiry would begin with the desired human conditions and social structures, with processes aimed at fulfilling human development and dignity, and would proceed to elicit diverse social visions from a heterogeneous sample of creative thinkers. The outcomes would have tremendous value in their own right, but the process would also complement modelling of economic and physical phenomena, interacting with them by setting up a dialectic (missing from earlier models) in which diverse social arrangements would drive, be explicitly incorporated in, or be compared with, the models. The process would test not only model feasibility but also the modellers' assumptions and implicit world visions (at least, those aspects of the visions capable of being modelled would be tested, thereby enriching the modelling process).

The Clark group undertook an initial experiment, involving a review of the social content of the first generation of global models. As an aid in comparing the social content of the models, we constructed a set of attributes that (arguably) might be used to characterize a sustainable society. We sought to create a frame of analysis by which very different social visions could be compared (see below). This frame included some components typically treated (e.g. population) as well as some less-obvious attributes (e.g. equity, views of nature). A striking lesson of this process was the difficulty of creating an analytical approach that does not lose the richness of texture and interconnections among attributes or components.

Previous listings of important qualities of social visions include everything from Maslow's hierarchy of needs (Maslow, 1959) to transportation systems, from political change to individual spiritual fulfilment. Such a wide range of factors might help to begin to address questions such as those posed above – what it would be like to live in such a society, and whether anyone would want to do so. For the sake of manageability, this wide sweep of characteristics was pared down to a limited set of variables that could be used to construct a comparative matrix. In the interests of 'getting a handle' on what we viewed as the multidimensional nature of social visions, however, we narrowed these wide-ranging themes to a set of somewhat conventional attributes (cf. Jessen, 1981, pp114–116), as well as several that are less conventional. Finding a balance – between having criteria that structure the analysis without overly structuring it – proved difficult. For the limited purpose of reviewing the global models, however, they proved useful in dealing with complexity.

The models

We examined the reports of six global modelling efforts and one related environmentalist tract in an attempt to extract the social visions, if any, contained therein. The models are the two Club of Rome efforts, *Limits to Growth* (Meadows et al, 1972) and the update, *Mankind at the Turning Point* (Mesarovic and Pestel, 1974); Kahn and colleagues' Hudson Institute rebuttal from the right, *The Next 200 Years* (Kahn et al, 1976); the Latin American rebuttal from the left, the Latin American World Model or LAWM (Bruckmann, 1976; Herrera et al, 1976), also known as the Bariloche model (Gallopin, 2001); Leontief's economic model for the UN (Leontief et al, 1977), and the Carter administration's compilation of US government models in the *Global 2000* report (USCEQ, 1980). The environmentalist report is *Blueprint for Survival* by Edward Goldsmith and the other editors of the *Ecologist* (1972).

None of these models is explicitly social; they examine neither social structure nor the lived experience of people. All focus primarily on the economic and environmental implications of global development (Leontief et al, 1977), on the compatibility of economics and natural resources, and on demography as an input governing economics. The variables used are primarily those for which numerical data were relatively readily available. They all use basically the same variables – population growth, production, income, materials/energy consumption and sometimes pollution. Each model or report was created for a specific and limited purpose.

In no case was the primary purpose of a model the elaboration of a social vision. The Latin American and UN (Leontief et al, 1977) reports make no claim to be anything other than economic models; the input–output structure of the Leontief model treats society as a 'black box'. Other model reports specifically state that they do not address social issues, claiming, for example, to be explicitly 'concerned with biophysical matters, as opposed to social, political, and economic developments' (USCEQ, 1980, pp2, 275), and noting that 'no formal model of social conditions' is offered (Meadows et al, 1972, p174).

Even *Blueprint for Survival*, which claims to offer a vision for a radically different and stable society, offers few specifics beyond a call for decentralization; its main emphasis is on resource conservation and a steady-state economy. Its section on ecological disruption is primarily devoted to denouncing technology, while the discussion of social disruption is limited to northern social pathologies such as crime, drug abuse and suicide. Similarly, the Second Club of Rome model includes 'group' and 'individual' strata in each regional model but the model results are concerned with the usual issues – population, food, energy and income. [Nor does this change in the more optimistic second-generation treatment; see Meadows et al (1992)].

A preliminary examination forces acknowledgement of the non-social nature of these models. The reports are dominated by a concern with material and readily quantifiable issues. Although the models are, in some sense, views of the future, their anchors in current data, extrapolations therefrom, and moral or political judgement about the result leave the reports with the distinct flavour of the present. In so far as they have social concerns, these seem to centre around an exploration of limits or material and economic breaking points, rather than an exploration of the nature and qualities of human institutions, values or experiences. They ask what limits of stress this society can endure and what will make this society collapse; they do not ask about intrinsic cultural and individual qualities, about human experiences or about that which is valued. As such, they provide little or no guidance to the central directions by which people can create dignity, liberation or fulfilment or how these may be possible in different nature–society settings.

Evaluating the Models

As mentioned earlier, we formulated a set of criteria for social visions to characterize the essential features of a social vision and to provide a basis for comparing and evaluating the models. We agreed that the overall social vision created by an author or research group could be characterized in terms of scope, bias, scale, tone and vantage point, among other qualities. Within the vision, major spheres of concern – human/nature relationships, material concerns, social organization and value systems – could then be analysed. The specific variables we selected include the following: view of nature, view of human nature, view of time, valid modes of understanding, view of society and social goals, agent of change, population, equity, relative rights and responsibilities of individual and society, political organization and authority, institutions, economic system and exchange, technology, lifestyle, spatial linkages and security. These categories may be loosely grouped as philosophical assumptions, social organization and material arrangements (see Table 20.1).

Table 20.1 *Attributes of social visions*

Philosophical assumptions

- view of nature
- view of human nature
- view of time
- valid modes of understanding

Social organization

- view of society and social goals
- agent of change
- population
- equity
- relative rights and responsibilities of individuals and society
- political organization and authority
- institutions
- lifestyle
- security

Material arrangements

- economic system and exchange
- technology
- spatial linkages

The social content of the models

The results of analysing the models using this framework are summarized in Table 20.2. Several points should be noted. For many of the categories, 'not addressed' would be the most appropriate notation. If a diligent search of the text revealed even some small mention of the topic, however, it was considered an indicator of the authors' attitude and incorporated into the matrix. As a result, we have in some cases characterized a model on the basis of a brief passage. Mesarovic and Pestel, for example, devote a brief space to their view of nature, waxing eloquent about human survival depending on living in harmony with the web of life. We have repeated these phrases in our characterization, for they express the explicit views of the authors; however, the overall tenor of their report and the model itself treats nature solely as a collection of resources. In other cases, where we found no specific mention in the text but an obvious characterization could be extrapolated from the overall tenor of the text, we have done so. None of the six models, for example, overtly expresses a conception of time, yet all implicitly treat it as linear.

Organizing the attributes into the aforementioned loose categories – philosophical assumptions, social organization and material arrangements (Table 20.1) – permits some general observations. In the sphere of material arrangements, the models are fairly forthcoming, offering moderately detailed visions of economic and technological conditions and at least a general sense of spatial linkages. Philosophical assumptions are, for the most part, not explicitly addressed at all, but implied stances may in many cases be gleaned from the overal tenor of the text,

Table 20.2 *Comparison of social attributes of first-generation global models*

	Meadows et al (1972)	*Mesarovic and Pestel (1974)*	*Kahn, Brown and Martel (1976)*	*Goldsmith et al (1972)*	*LAWM[a] Herrera et al (1976)*	*Leontief, Carter and Petri (1977)*	*USCEQ[b] (1980)*	*Clark and Munn (1986)*	*Brown (1981)*
Nature	Resources; waste sink; scarcity	Harmony; web of life; human survival; scarcity	Warehouse; conquer; monitor; manage	System; complexity; stable; self-regulatory; predictable	Resources	Economic factor; resources; waste sink; not limiting	Life support; resources	Garden; Gaia; resources	Harmony; resources
Human nature	Culture; creativity, incentive = improvement; basic good	Basic goods; can change; do right thing	Self-interest; incentive = struggle; satisfaction; test/stimulate; structure/purpose; engineered	Part of nature; adaptation; natural law; community; belonging	Not addressed; solidarity; progress	Not addressed; implied – *Homo economus*	Not addressed; implied – part of nature	Goodness; utilitarian	Rational; do right thing
Time	Mechanical; interval; open future; 70 years	Linear w/ cycles; narrowing options; 50 years	Linear: sequential developing progress; slowing change	Not clear; critical point; industrialism as historical aberration	Linear; history open-ended and depends on human will; process as original	Linear	Linear; future as extrapolation of present; narrowing options	Linear; holistic	Linear
Valid modes of understanding	Rational science; analyse, then manage; science engaged in morals	Holism; science; objective + subjective; science engaged; participation	Rational; engineering; objective; science; morality	Culturally determined; may be many; science serves ecosphere	Analytical; rational; economic models; ideology	Analytical; rational; economic models	Analytical models	Science; interdisciplinary; surprises; linear argument for non-linearity	Rational

Table 20.2 *(continued)*

	Meadows et al (1972)	*Mesarovic and Pestel (1974)*	*Kahn, Brown and Martel (1976)*	*Goldsmith et al (1972)*	*LAWM[a] Herrera et al (1976)*	*Leontief, Carter and Petri (1977)*	*USCEQ[b] (1980)*	*Clark and Munn (1986)*	*Brown (1981)*
Society and goals	Homogeneous system to be managed; open future; participation; can set limits; leisure; freedom from struggle	Sustainable material and spiritual; cooperation; organism; can adapt	Stages; high morale; dynamism; consensus; smooth function	Stability not expansion; analogue of nature; system; hierarchical; functional	Goals = equity; produce for need not profit; social (not state) control	Development; wealth; employment; NIEO;[c] justice; rationality	Not addressed (explicitly); highly evolved system	Not addressed	Not addressed
Agent of change	Moral resources; values; gradual	Individual or society? Values; internal crisis; 'public figures'; 'political leaders'	Positive images; individual; influence not choice	Economic decentraliza-tion; con-scious restructuring; education in new values	Not addressed; locus = property and production – structural changes	Not addressed; economic restructuring as implied driver	Information; planning; analysis plus political will	Managers; also technologi-cal, institutions, research; having vision	Individuals; having vision
Popu-lation	Out of control; major threat by 2050	Serious problem; 35 years to fix	Rate high but declining; not a problem; economic development will slow growth; colonize space; 7–30 billion	Major threat; wealth will not necessarily slow; ZPG;[d] 3.5 billion maximum; halt immigration	Need to slow; economic development as precondi-tion; focus on basic needs; urbanization	Not a big problem; wealth slows growth; economy can keep up	Major problem; reducing carrying capacity; 10 billion under 'intensive manage-ment'	A problem but not too serious; still time 8–11 billion	Must stabilize at 8 billion

Table 20.2 *(continued)*

	Meadows et al (1972)	*Mesarovic and Pestel (1974)*	*Kahn, Brown and Martel (1976)*	*Goldsmith et al (1972)*	*LAWM[a] Herrera et al (1976)*	*Leontief, Carter and Petri (1977)*	*USCEQ[b] (1980)*	*Clark and Munn (1986)*	*Brown (1981)*
Equity	Social goals: justice = basic needs	Narrow income gap; we're all connected	Gap to persist; inequity nor mal, healthy, moral	Not addressed; implied goal	Main goal	Main goal	Increased	Not addressed	Need for redistribuon, not growth
Rights and responsi-bilities	Basic needs; produce food; moral resources; behavioural restraint; trade-off of freedoms	Not addressed; share global wealth and resources; change values	All share in market levers of control; individual struggle for meaning; individuals maintain morale	Maintain social economic stability; restrain consumption, reproduction; provide goal structure – prestige	Basic needs; priority = needs; universal rights; work collectively	Basic needs; benefits of development	Not addressed	Not addressed	Individuals responsible to shape society; emphasis on voluntarism
Political organiza-tion and authority	Not addressed; nationstate; define values then choose; participation	Nation state; global cooperation; reduced polarization	Nation state; no world government; reduced competition; manipulative power; elite rule; public lacks expertise; democracy, if 'republican virtues' re-established	Decentralized; local, small scale; participation; peer pressure; only unstable society needs strong authority	International socialism; nationstate; participation	Nation state; internally restructured LDC;[e] North surrender power to South	Not addressed; nation-state	More of the same	Not addressed

Table 20.2 *(continued)*

	Meadows et al (1972)	*Mesarovic and Pestel (1974)*	*Kahn, Brown and Martel (1976)*	*Goldsmith et al (1972)*	*LAWM[a] Herrera et al (1976)*	*Leontief, Carter and Petri (1977)*	*USCEQ[b] (1980)*	*Clark and Munn (1986)*	*Brown (1981)*
Institutions	Institutions to constrain growth; humans will develop unknown institutions	Not addressed; institutions put information before public for action; institutions for global crisis prevention	Specialized; technocratic; impersonal; decline of family and community; innovation institutionalized; control of serendipity/ synergy; privatization; family, economic exchange superseded	Not addressed; 'Movement for Survival' Coalition	Nationstate; cosmopolitan world organization	Not addressed; institutions to close North–South gap	Institutions for long term; global environmental analysis	Better use of existing ones; formal and informal	Not addressed; emphasis on planning

Table 20.2 *(continued)*

	Meadows et al (1972)	*Mesarovic and Pestel (1974)*	*Kahn, Brown and Martel (1976)*	*Goldsmith et al (1972)*	*LAWM[a] Herrera et al (1976)*	*Leontief, Carter and Petri (1977)*	*USCEQ[b] (1980)*	*Clark and Munn (1986)*	*Brown (1981)*
Economic system and exchange	No-growth; services; human needs; planning implied; resource efficiency; balance of consumption/population; surplus for arts and leisure	Organic model; cooperation; planning implied; restrained growth in North	Growth for South to catch up; North model as universal; technology, institutional, morale as key; eventual slowing of demand	Steady state; stock not flow resource efficiency; minimal disruption; local control; small scale; correspondence of economic/real costs/values	Scarcity = technopolity; human needs; socialist redistribution; social determination of needs; planning; eventual slowing of growth; growth not answer	Develop under-used resources; NIEO[c] to close North–South gap; self-reliance; pollution abatement	Decelerating growth	More of the same	Steady state; intragenerational welfare; durability; high-tech, high design; resource efficiency; conservation; labour-intensive; generalization
Technology	Not cause or solution; useful technofaith as diversion; shape by social need/priority	Not cause or solution; useful; restrain by social concerns	Good to control nature; main human resource; Faustian bargain	Incompatible with stability; anti-ecological – simplifies complexity; hubris; increases vulnerability; should serve decentralization	Avert scarcity; prevent pollution; social control; progress essential	Narrow North–South gap; expand resource exploitation; pollution abatement	Solution available but politically constrained	Brings environmental changes, good and bad	Decentralized; soft-path renewables

Table 20.2 *(continued)*

	Meadows et al (1972)	*Mesarovic and Pestel (1974)*	*Kahn, Brown and Martel (1976)*	*Goldsmith et al (1972)*	*LAWM[a] Herrera et al (1976)*	*Leontief, Carter and Petri (1977)*	*USCEQ[b] (1980)*	*Clark and Munn (1986)*	*Brown (1981)*
Lifestyle	Art and leisure; leisure time essential for higher pursuits	Standard of living, not just material; less materialism; conservation ethic; social, moral, organizational, scientific growth	Useless work; hedonism; gaming, art, education, ritual, social interaction; secular with romantic, mystic counter-reaction	Personalized; intimate; self-reliance; pleasure of community; non-materialistic; reintegrated work/home	Not based on consumerism; rich to reduce consumption	Lower Northern consumption; higher Southern consumption	Not addressed	Not addressed	Non-materialistic; simple, frugal; personal/social development; integrate home/work; telecommuting and bicycles; rich/poor convergence
Spatial linkages	Not discussed	Diverse regions; inter-regional cooperation; diversity key to survival, and to moral strength	Homogeneity – 'they' become like 'us'; modernism; links impersonal, business-like; urban/suburban globe; huge economic scale	Decentralized but linked; small scale; diverse rural/urban mix; material self-sufficiency	Autarchy; North–South interconnected; economic complementarity	15 political/economic regions; regional interaction; international trade	Food, energy imports; use distant resources; unaware of environmental impacts	Region-to-globe links; global noosphere	Reversed global interdependencies; local self-reliance; population rural and dispersed; decentralized

Table 20.2 *(continued)*

	Meadows et al (1972)	*Mesarovic and Pestel (1974)*	*Kahn, Brown and Martel (1976)*	*Goldsmith et al (1972)*	*LAWM[a] Herrera et al (1976)*	*Leontief, Carter and Petri (1977)*	*USCEQ[b] (1980)*	*Clark and Munn (1986)*	*Brown (1981)*
Security	Not addressed	Disarmament; without reform, conflict will bring nuclear holocaust; confrontation = dysfunctional	Increased violence due to boredom; weakened Northern defences due to false sense of safety	Internal disintegration; chaos of industrial society; chaos leads to dictators, war; deviant behaviour absent; stable society	Not addressed	Not addressed	Tension; vulnerable people; production system; vulnerability to climate change	Not addressed	No war; conflict and fear = environmental not military; UN peacekeeping

a. LAWM, Latin American World Model.
b. USCEQ, US Council on Environmental Quality.
c. NIEO, New International Economic Order.
d. ZPG, Zero population growth.
e. LDCs, Less-developed countries.

with 'view of human nature' being the most difficult to discern. The treatment of social organization is mixed. Equity, and especially population, are central issues in virtually all of the reports and are addressed in some detail. None of the reports, however, offers a comprehensive or coherent picture of social goals, processes, and relations: the attributes listed in Table 20.2 are a collection of brief and disparate mentions culled from the texts. The same scattershot approach involved in the models applies to politics and institutions, with the difference that these are at least recognized by the modellers as important topics – not that this recognition results in any comprehensive or systematic treatment. Finally, lifestyle and security issues generally receive brief mentions, but are not elaborated.

Further generalizations may be gleaned from a more detailed look at each of the attributes. All of the models treat nature primarily as a bundle of natural resources. None of the reports includes an overt discussion of conceptions of time or notions of legitimate modes of understanding, but implicit in all of them is a linear view of time and a reliance on rational, analytical scientific thought and quantitative data.

The models are fairly evenly split on whether individuals or society as a whole, values, or economic structure drive social change, but none of them explores this issue beyond the level of assertion. The reports also split on the issue of whether population is a problem. All models except those by Kahn et al (1976) and Goldsmith and colleagues (1972) state explicitly that equity is a major social goal, and the latter implies it. The notion of equity adopted is itself limited, focusing on the admittedly pressing issue of inter-generational equity and particularly apparent distributional inequalities among nationstates. On the other hand, the complexity of equity deliberations such as the valued goods to be distributed, the relevant populations used to structure analysis and the philosophical principles by which to define social justice receive scant attention. Those studies that propose means of achieving equity advocate economic growth (Kahn et al, 1976; Bruckmann, 1976; Leontief et al, 1977; Mesarovic and Pestel, 1974) or redistribution (Goldsmith et al, 1972, implied by Bruckmann, 1976; Herrera et al, 1976; Leontief et al, 1977). Most of the models advocate economic growth, although Meadows et al (1972) and Goldsmith et al (1972) oppose it, and Mesarovic and Pestel (1974) call for a different kind. With the exception of Kahn et al (1976) and Bruckmann (1976), all agree that technology is not the solution to environmental and economic problems, with Leontief taking a middle position. It is interesting to note that, except on the issue of equity, the positions taken by Kahn et al (1976) and the advocates of the LAWM model are the most alike: they agree that population growth is not a problem and that resources are not limiting; they advocate economic growth, believe in technological solutions and argue that environmental concerns are secondary to economic ones.

As mentioned above, for those attributes (e.g. philosophical assumptions, social organization) central to a deeper understanding of society, the models take a haphazard approach, implicitly assigning peripheral importance to them. On the question of 'human nature,' for example, all but Kahn et al (1976) – who emphasize struggle and self-interest – imply a belief in the basic goodness of people. Little attention is given to the nature and goals of society or to the structure of the relationship between the individual and political society. Disparate details related to political organization and calls for international cooperation appear in the various reports, but issues of power, authority, conflict and security are generally not addressed at all, or are addressed only very briefly. The same is true for institutions – only Kahn et al (1976) really treat them at all, and their analysis is sketchy. The models make more mention of lifestyle, with many general calls for less materialism and more creative leisure activities, but this is for the most part left to individual decision making and not linked to social and economic structure or to broad social policies. Finally, spatial linkages, if treated at all, are discussed in general terms, such as degree of centralization and homogeneity, or in terms of North–South economic relations, despite the growing evidence of the importance of regional linkages to the global economy and social movements.

Model visions

From these observations (and the details in Table 20.2), it is clear that – even using relatively conservative and conventional categories and giving the modellers the benefit of the doubt by extracting minor details and extrapolating from the tone of the text – the models fail badly to confront social or philosophical issues, much less to probe them in any depth. The modelling approach is based on quantitative analysis using largely linear extrapolations from the present. Its materialistic (as opposed to relational or experiential) bias results in an avowedly utilitarian approach and a largely managerial orientation. The resulting emphasis is on just a few variables – population, resources, pollution levels, technology and economy – with some speculations about their social meaning, in terms of wars, crises, international 'tensions', 'overshoot' or 'collapse.'

Even within the mode of extrapolation from the present, little or no attention is given to current social trends, with the exception of growing global divisions between rich and poor. The major non-demographic social factors for which data exist – such as health, education and settlement pattern – receive minimal attention. Structural considerations related to politics, social norms, the organization of political economy and institutions are only peripherally and sporadically treated; issues such as human rights, cultural diversity, psychological fulfilment, personal relations and freedom are not addressed at all, and neither are environmental or psychological issues, such as the impacts of an increasingly artificial and homogeneous environment (Mumford, 1970, 37 ff) and the social choice of reliability over resilience (Blaikie et al, 1994; Timmerman, 1981).

The first-generation models performed the invaluable services of initiating discussion about possible economic and environmental futures; of taking a global instead of a national perspective; of treating the planet as a single, integrated whole; and of taking a long-term view. As our review demonstrates, however, the approach of these models was inherently limited by the specific rationality and methodology employed. Global problems were approached as essentially economic and resource based, resulting in limited parameters of concern focused largely on material and energy flows. Population, and society in general, were seen as relevant only in so far as they generated (or were affected by) these flows.

Models: the second generation

Efforts to look at the global environment/development picture have become more sophisticated in the 1980s and 1990s. The authors analysed several studies from researchers associated with the International Institute for Applied Systems Analysis (IIASA) and the Worldwatch Institute, applying the same list of attributes used to analyse the models. Table 20.2, above, includes the social visions contained in pieces written in the 1980s by Lester Brown (Brown, 1981; Brown et al, 1990) and by Clark and Munn (1986) on the prospects for a sustainable global future.

The pieces examined demonstrate a more complex view than the models but share a similar focus. Like the modellers, Brown and his Worldwatch colleagues concentrate on population, resources and material/energy flows. Explicit social concerns are limited to an emphasis on lifestyle (presumably in industrialized countries) and the argument that individual behaviour can reduce demand on global resources. Broader social, organizational and structural issues are not addressed. The Clark and Munn piece differs from the first-generation models in its non-linear approach; greater concern with institutions; and the treatment of uncertainty, surprise and discontinuities in the generation of knowledge and its uses. The major concerns, however, remain population and resources, and no distinct social vision is generated.

Although sharing a similar focus with the early models, these more recent efforts attempt to improve on earlier studies by acknowledging the role of uncertainty and surprise in projections and by experimenting with other techniques, such as backcasting and constructing future histories. The importance of surprise was emphasized by the failed projections of some of the early models, and has received significant recent attention (Glantz et al, 1998; Kates and Clark, 1996; Schneider et al, 1998; Toth et al, 1989). Global systems theorists have come to recognize that, for systems near thresholds of change, deterministic analysis no longer works as the system becomes unpredictable and stochastic elements predominate, and inherent indeterminism sets in (see, for example, Gallopin and Raskin, 1998). Research concerned with systems undergoing change must assume the prevalence of discontinuous changes and surprise and be more concerned with uncertainty than predictability. Perrings (1987, p11) distinguishes between 'the probabilistic uncertainty that assumes away our inability to foresee the effects of our actions' and 'uncertainty before ignorance, novelty, and surprise … [arising] from the system's existence in real, historical, irreversible time'. The time in question is, in Georgescu-Roegen's terms, not *time* (the mechanical measurement of an interval) but rather *Time* (the continous succession of moments) (Perrings, 1987, p111). Whereas statistical prediction may have some relevance in *time*, it has none in *Time*. The probabilistic approach assumes the future to be a 'stationary stochastic process' in which a pre-image of the range of possible outcomes exists and various possible futures become rival hypotheses to be tested (Perrings, 1987, p113). But true uncertainty assumes an incomplete set of images of the future and denies that the future is knowable from the past.

The Swedish work on 'surprising futures' (Svedin and Aniansson, 1987) and the IIASA project to develop 'surprise-rich scenarios' (Toth, 1995) are both attempts to address these concerns and to face head-on the major shortcomings of projections. Schneider and Turner (1995) hosted an Aspen seminar on surprises in global environmental change in 1994, aimed at identifying a rich panoply of types of surprise, an endeavour to which Kates and Clark (1996) have also contributed. Despite these helpful advances, the primary concern is still with population, economic growth, technology, energy use and agricultural production. Although much more detailed and sophisticated than earlier modelling efforts, and vigorously developed during the 1990s, the current second generation of models and their scenarios do not include social, cultural and institutional developments and they lack the requisite variety needed to capture possible worlds reflecting the dynamic interplay and different social and cultural groups (Thompson and Rayner, 1998). The models and scenarios still rely heavily on conventional socioeconomic indicators, such as population, energy production, SO_2 and CO_2 emissions, labour force, production capacity, industrial emissions, agricultural production, forest production, water demand – plus a long list of environmental indicators, although more social attributes are being worked into the impacts. Future histories, as in *Beyond Hunger in Africa* (Achebe et al, 1990), are richer and explore a wider range of concerns, including cultural ones. Meanwhile, the *process* for developing integrated assessments also remains disputed; none of the second generation of models is being developed in close conjunction with the decision makers and others who will use them. As a result, they remain politically simplistic and naive and lack the flexibility needed to represent the interests of various interests and social groups over space and time (Rotmans and Dowlatabadi, 1998, p341).

Several promising developments in the current global modelling efforts deserve mention. The 2050 Project undertaken by the World Resources Institute during the 1990s intentionally sought to broaden the social visions involved in alternative future worlds. So, in 1993, project members solicited nominations from a range of colleagues and the World Council of Indigenous Peoples and other NGO leaders to prepare essays envisioning positive futures for their regions or locales. Some 52 'envisionaries' from 34 countries eventually submitted essays in five languages, with developing countries substantially over-represented. The results provide a highly suggestive tapestry of the potential richness of global visions (Nagpal and Foltz, 1995). Hammond (1998) also subsequently examined three scenarios, or worldviews, of the future which he entitled the *market world* – a world of rapid economic growth and technological innovation; a *fortress world*, in which future market failures create a future in which enclaves of wealth and prosperity coexist with widening misery, desperation and conflict; and a *transformed world*, where greater sharing of power and fundamental social change transforms governments and institutions. In a separate effort, Costanza (1999) identifies four 'future histories' – 'Star Trek', a vision of technological optimism, free competition and unlimited resources; 'Mad Max', the technological scepticist nightmare come true, when technology and consumption go bad; 'Big Government', in which protective government policies override the free market; and 'Ecotopia', the low-consumption, sustainability vision.

The PoleStar Project of the Stockholm Environment Institute, referred to above, has also sought a broader framework that includes the conventional IPAT (impacts = population × affluence × technology) drivers of change but also a broader array of social variables (international equity, national equity, welfare, conflict, poverty and political instability), designed to capture the 'interlocking crises' of concern in the Brundtland report (WCED, 1987). PoleStar identifies and analyses three archetypal scenarios of the future – *conventional worlds*, a class of scenarios that assumes that current global trends play out without major discontinuity or surprise in the evolution of institutions, environmental systems, and human values; *barbarization*, scenarios in which fundamental social change occurs but brings great human misery and collapse of civilized norms; and *great transitions*, in which fundamental social transformation occurs but a new and higher stage of human civilization is achieved (Gallopin et al, 1997). Events with the capability to redirect beliefs, behaviours and institutions away from some visions of the future and toward others are posited, as are *sideswipes*, major surprises (e.g. world wars, miracle technologies, pandemics) that greatly alter trends toward particular outcomes (Gallopin and Raskin, 1998; Raskin et al, 1998).

Although these and other efforts of the 1980s and 1990s have come a long way in improving on the earlier models, mostly they are still bound by their focus on a limited set of traditional (if important) variables. It seems fair to conclude that the models have unduly set the terms of social and political debate, defining a sustainable global future largely in terms of population, resource and economic relationships. In other words, the debate and the ongoing work in integrated assessment, with several notable exceptions, remain unduly limited in social content and visions. In this regard, the explicit attention by Robinson in chapter 15 [of *Global Environmental Risk,* Earthscan, 2001] to identify social principles of sustainability is a step in the right direction, as are the use of differing cultural perspectives by the RIVM group in The Netherlands to enrich the underlying assumptions of integrated assessment (Asselt and Rotmans, 1996) and the efforts of the US Interagency Working Group on Sustainable Development Indicators (1998). In envisioning alternative futures, in short, the net needs to be cast to include a larger array of ideologies, religions and cultures but also historians, anthropologists and humanists; of course, some of these will generate dark views of the future (Kaplan, 1994).

The ideology of futurism

Although global models have largely set the stage and defined the terms for current debates on global futures, the formal 'science' of futurism represents the primary institutionalized means for peering into the future. Most futurists have concentrated on the specific interests of their clientele rather than on broad social alternatives or long-term global futures. This professionalized and institutionalized version of the futurological endeavour has attracted substantial criticism of the narrowness of vision.

One critic equates futurism with the institutionalization of prophecy (i.e. forecasting) in an 'attempt by self-appointed experts to rationalize the future' and to impose their own narrow, mechanistic worldview. The prophetic endeavour – and its tendency to reflect the needs of corporate, military and state institutions – trivializes and depersonalizes the future, ignores diversity as too difficult to capture and control, and produces restricted visions that attempt to monopolize the future in the hope that it will resemble the present status quo (Dublin, 1991, p248). Critics early on noted a restriction of the range of alternative futures discussed; an ethnocentric preoccupation with a single society (an idealized, post-industrial North America); as well as tendencies towards technological determinism, mystification and over-quantification; a readiness to apply technical fixes to social problems; and an uncritical acceptance of the status quo (Miles, 1978). The net effect is to empower further the already powerful, to perpetuate an interpretation of the world that serves particular interests and to frame problems so that only certain options are considered (Miles, 1978).

The critics demand a close scrutiny of futurist ideologies – an explicit identification and evaluation of 'what is being sought, by whom, and for what purposes' (Hoos, 1983, p61). Although some futurists have called for extension of the 'futuristic mission farther into the social domain and toward a much larger constituency of stakeholders' (Adelson, 1989, p31), such a 'populist futurism' may also be problematic. Although more participation might result in people having increased control over their own destiny and might produce futures more responsive to wider interests, the means to accomplish this 'may be actually employed as manipulative tools for legitimating the status quo through pseudoparticipation', exchanging fatalism for people's participation in the management of their own exploitation (Miles, 1978, p81).

Forecasting tends to minimize the intrinsic uncertainty of the future by attempting to reduce it to probability. It typically founders on the shoals of institutions and value systems. Although some futurists (e.g. Adelson, 1989; Simmonds, 1989) argue that current organizations no longer seem to work, most futurists work for existing institutions. Adelson (1989, p35) argues that futurists, instead of designing policies for existing organizations, should concentrate on a transition to new institutions, and that efforts to look to the future should be less bureaucratic and institutional and more 'artistic, entrepreneurial, expressive, pragmatic, case-by-case, constructive … visionary'. Adelson (1989, p33) further advocates thinking from the design disciplines, not the sciences – a sentiment echoed by Utopian theorists Manuel and Manuel (1979, p813) in their observation that architecture, not science, provides the most imaginative and authentically Utopian creations of the age. Another futurist points out that, in the chaotic context of changing value systems, forecasting is not very useful: 'All we possess are remnants of previously demolished value systems … inconsistent collections of irreconcilable bits and pieces from the past' (Michael, 1989, p82). Norgaard (1988, p613) describes this as the gradual demise of *Progress* – 'a great carpet under which old beliefs and new contradictions were swept for centuries' – and its likely replacement with the meta-belief, *Sustainability* – the 'clarion of a new age'. Faced with multiple, confusing and uncertain signals, individuals gravitate towards interpretations compatible with their personal worldview – a process that forecasts do not capture.

Some futurists have themselves claimed that the prophetic endeavour, or forecasting, is inherently untenable when applied to society. Forecasting is meant to enhance coherence, but this is impossible in a modern society that is internally fragmented and increasingly incoherent – epistemologically, socially and psychologically (Michael, 1989, p79). For other futurists, a prescriptive or normative futurism offers an alternative to technocratic extrapolations of the status quo. Coates and Jarratt (1989), for example, advocate a prescriptive, ideological and ethical focus, calling for more emphasis on outcomes and less on driving forces. Others dismiss normative futurology as a '*rapture of the future*' which, in the case of social prescription, 'founders on the axiomatic "we"' (Kern, 1987, p216).

Alternative futures

Underlying these criticisms of formal, mechanistic futurism and its traditional constituency is an association of the prophetic, predictive endeavour with goals of manipulation and control (e.g. Dublin, 1991). Such observations should serve not as reasons to disengage from all exploration of future possibilities but rather as warnings. We distinguish between a controlling futurism and the process of creating social visions. We need to eschew blueprints by which some groups control others; rather, we should create means for thinking through the consequences of current actions and for stimulating a sense of open possibilities, of wonder and of power to act.

Although a desire for control serves as a powerful motive for peering into the future, it is not the only alternative: a sense of wonder or of responsibility may also serve as motives. A sense of wonder permits exploration of alternate possibilities while retaining a strong sense of humility toward the future – and the conviction that it will inevitably be more amazing than we can imagine. A sense of responsibility may guide attempts to add the consideration of long-range impacts to present actions, and it may inspire present activities to be conducted in a manner that leads to morally defensible future directions. Envisioning the future and emancipatory risk assessment should be conducted in such a way as to enrich empowerment and a sense of ability to create one's own life.

Alternative motivations are compatible with a diversity of social visions. Multiple visions encourage continuing clarification and communication, and contestation and critique of alternate futures; they also provide a forum for examining the possible ramifications of present proposals, decisions and actions. For multiple visions of alternative futures to flourish, it is necessary to bring diverse perspectives to the table. People operating from different basic assumptions will tend to articulate a multiplicity of social visions; those with alternative views of the present will tend to envision alternative futures. Only by such a multiplicity can there be real choice, or even meaningful debate.

Envisioning Alternative Futures

We have asserted the desirability of an active and broad-based exploration of the widest possible range of imaginable futures. In the context of global environment and development concerns, the envisioning of alternative futures – and exploration of their implications for peoples' lived experience – is an essential component of the hope for a sustainable world. Current processes of envisioning, the content of visions and the political frame for both imaging and images are incapable of creating a rich range of possible futures. Despite attempts at 'backcasting', as reviewed in Robinson and Slocombe (1996) and Mulder and Biesiot (1998), the modern approach to the future is symbolized by a technocratic and economic style and a narrow focus to global models and formal futurism. Social institutions, processes of social change, and human values and aspirations are still rarely at centre stage (but see Robinson et al, 1996a).

The reliance on a single approach to examining possible global futures – modelling – has, in our view, promoted a narrowness and sterility in the imaging process. Complementary or conflicting images – derived from anthropology, novels or paintings, for example – have not yet become relevant to debates on global futures. Despite the goal of some modellers to initiate public debate and stimulate action (Rotmans and Dowlatabadi, 1998), current approaches have too often depicted securing the planetary future as a management challenge properly addressed by experts.

An urgent need exists to enrich this debate by expanding both the content and the form of discussions about global futures. The process of envisioning and debating the future of the planet needs to be democratized and diversified, just as we need emancipatory risk analysis. There is a need to expand the debate into everyday life and to put everyday concerns on the agenda, but also for the discussion itself to become a part of everyday life rather than the exclusive domain of specialists.

In the discussion to follow, we take the modest step of arguing for a broader content in social visions, an expansion that necessitates much wider participation. We argue for the legitimacy of multiple forms of communication, and use the example of science fiction to illustrate the relevance of one non-academic, popular-culture form of vision creation.

Broadening content and form

Enriching the content of future visions and broadening participation may be addressed on several levels. Although the ideal is a wide-ranging democratic discussion – taking place in the world's cities and villages, fields and marketplaces, bars and watering-holes, schools and workplaces, meetings and media outlets – even the confines of policy circles and academia provide ample scope for expansion.

Content: social science

Although a few scholars in the social sciences have come forward to participate in discussions about environment and development or human dimensions of global change, many of the pertinent findings of the social sciences other than economics (e.g. sociology, anthropology, political science, human geography, psychology) are still not incorporated. It is not clear how existing research on cultural identity, social change, political cultures, nature–society relations, international politics or individual development can enrich our understanding of possible futures – a lack which is itself an indictment.

The gap arising from the paucity of attention to prominent social science theory is compounded by the lack of attention to, or visibility of, less-known innovative voices outside the social science mainstream. Those whose views might expand the conventional range of debate, or who question hallowed assumptions, are usually not heard. People doing creative work on a number of theoretical fronts, who may not have published on the subject of planetary futures but who deal with relevant topics, could greatly expand notions of what is possible. For example, critical theorists and oppositional political economists have not chosen, for the most part, to apply their efforts to the economy, institutional structures, politics or social arrangements of alternative futures, nor have they always been effective when choosing to do so. An encouraging counter-example is the flourishing of a vigorous school of ecological economists, who have brought a new, valuable perspective to economic questions. In general, however, theorists outside the confines of conventional disciplines – such as bioregionalists and others concerned with regional and cultural diversity, contemplators of the meaning of place and technology theorists – conduct a largely unacknowledged parallel debate on environment and development.

Beyond the realm of theory, reservoirs of experience have been generated in praxis across a wide spectrum ranging from applied social sciences (such as development, design, architecture, planning, appropriate technology) to social and political activism. A truly enriched debate, one that includes 'passionate' as well as 'dispassionate' social science, would draw from (for example) proponents of bottom-up development, decentralization, local self-reliance; from advocates for the disadvantaged and people confronting poverty; from activists for grassroots environmental action, for community empowerment, for indigenous rights – and any number of other sites of activism. The engagement of activists and the participation of those often left out of the discussion (and especially those vulnerable groups who may disproportionately bear global environmental risks) will broaden the set of questions to be asked. Visions generated from the bottom are sure to challenge the view from the top.

Content: humanities and popular culture

Incorporating social science will bring neglected issues into focus, but the expansion of visions should not stop there. A broader conception should also include the humanities and even popular culture. Expanding the content of social visions to include a wide range of community and individual structures, relations, experiences and consciousnesses should draw on the richness found in literary, artistic, philosophical and spiritual expression. And just as visions drawing on the social sciences may gain from mainstream knowledge as well as the more innovative fringes and from the world of experience or praxis, both formal and informal expressions may contribute.

Can the critiques of postmodernist philosophers and literary deconstructionists be directed toward the positive task of envisioning alternative social futures? Can work by ethicists, philosophers and religious leaders on questions of individual and societal values and aspirations, absent from much of the global-futures discussion, make a contribution? As with social science theory and praxis, there is value in the work of practitioners as well as that of critics in philosophy and the arts; in artists' works and experiences as well as the theories of critics; in the experience of mystics as well as the concepts of theologians. Artists of all kinds can offer a diversity of communicative forms as well as creative new content.

Not only may insights into individual and social meanings be derived from academic work in philosophy, history, literature and the arts; from the work of writers and artists, performers and composers; but it may also come from popular culture, traditional knowledge, folk wisdom, myths and prophecies. Work in rural development, in women's studies and elsewhere has shown the value of folk and women's knowledge (e.g. Richards, 1985; Rocheleau et al, 1996; Shiva, 1994). In the West, popular culture has been recognized as an important source for the expression of contemporary social values (e.g. Browne, 1984).

Broadening the pool of communicative forms

In Western discussions about the planetary future, discourse has generally occurred in a single communicative form – scientific written texts. To the extent that an enriched and expanded envisioning process is desired, multiple forms of expression – including the qualitative, philosophical and artistic – must be encouraged. If the goal of creating holistic as well as reductionist, empathetic as well as objectified visions, is a valid one, then personal as well as impersonal styles of communication and visual, oral or kinetic forms of expression are also legitimate vehicles for conveying these visions. In fact, different forms of expression will be inherent in some of the efforts, suggested above, to broaden the content of visions by including art, popular culture or traditional knowledge. Future visions abound, for example, in American popular and traditional cultures, such as science-fiction novels, short stories, comics and films; Hopi prophecies; post-apocalyptic rock videos; and television shows.

Furthermore, as O'Riordan and Timmerman (chapter 14 *Global Environmental Risk*, Earthscan, 2001) show in their discussion of the paintings of Swedish energy futures, multiple forms of expression may also be used to gainful (and democratic) effect in the social sciences. Local non-governmental organizations (NGOs) and villagers in rural India have been using maps, models and time lines (made from local materials) to theorize the present and to imagine possible local futures (Mascarenhas et al, 1991). The Peace 2010 contest of the *Christian Science Monitor* received 1300 essays, written from the perspective of the year 2010, explaining 'how peace came to the world' (Foell and Nenneman, 1986). Policy exercises like those reported by Achebe et al (1990) use the literary device of alternative histories to construct alternate futures. The essays from diverse 'envisionaries' throughout the world as part of Project 2050 suggest the range of planetary futures that remain to be discovered and articulated (Nagpal and Foltz, 1995). Commentators from the South (e.g. Banuri and Marglin, 1993) see the roots of global environmental destruction in the power and violence inherent in the Western tradition.

Science, Imagination and Story

Within science, the notion of 'objective' rationality, untainted by society, personality or values, tends to be a caricature. Indeed, many scientists have long noted the artificiality of divisions between science and imagination. Popularizers of physics have, for example, pointed out the dissolution of orthodox dualities (matter versus energy, observer versus observed) in the 'new' physics – a physics that explicitly acknowledges that a complete understanding of reality lies beyond the capabilities of rational thought. Statements by Einstein and others on the role played in science by serendipity, inspiration, creativity and a childlike sense of wonder speak to the same point.

Although many scientists embrace qualities such as intuition and imagination, the mechanistic paradigm also survives, zealously protected by orthodox proponents with a tenacity likened by Lynn Margulis (1991, p213) to that of medieval monastic scholars. They reflect the relegation of intuition and imagination to the status of 'other' in much of Western society.

Imagination is an 'absolutely essential human faculty… If you truly eradicated it in a child, he would grow up to be an eggplant' (LeGuin, 1979, pp41–42). This is because of 'the mixture of realism and fantasy that lies at the psychic core of all humans' and the key role played by fantasy 'in the enlivenment and transformation of culture' (Tuan, 1990, p444). In fact, a free but disciplined imagination may 'be the essential method or technique of both art and science' (LeGuin, 1979, p41).

Storytelling is perhaps the most common imaginative expression. According to novelist Ursula LeGuin (1979, p31), stories are integral to human society:

> … [A] person who had never listened to nor read a tale or myth or parable or story, would remain ignorant of his own emotional and spiritual heights and depths, would not know quite fully what is it to be human. For the story … is one of the basic tools invented by the mind of man, for the purpose of gaining understanding. There have been great societies that did not use the wheel, but there have been no societies that did not tell stories.

The writer's exploration of her own imagination taps into Jungian archetypes – the collective unconscious of deep, shared experience that makes possible aesthetic, intuitive and emotional (as well as rational) communication (LeGuin, 1979, p78). This type of communication – accessing multiple dimensions of experience – is precisely what we argue is missing from discussions of the planetary future. Story provides one avenue (among many) for achieving it.

Stories of the future: science fiction

The accessibility and multidimensionality of the story medium serve both to promote a more democratic public discussion and to compensate for the failure of imagination reflected in the sterility of much existing debate about the future. Applied to the future, story adds participant observation to the available methodological repertoire.

A fiction of the future, argues literary scholar Robert Scholes (1975), responds to Sartre's call for literature to be a force for improving the human situation. Such a fiction combines entertainment and intellectual value – wedding idea and story, satisfying both cognitive (content) and speculative (narrative/escapist) needs, and providing suspense with intellectual consequences (Scholes, 1975, p41). Writers of such fiction produce imaginative models of the future, alternative projections that can give us some sense of the consequences of present actions and do so 'with a power which no other form of discourse can hope to equal' (Scholes, 1975, pp17, 74). Scholes asserts that what we need in all areas of life is more sensitive and vigorous feedback. A futuristic imagination 'will inform mankind of the consequences of actions not yet taken. But it must not merely inform, it must make us feel the consequences of those actions, feel them in our hearts and our viscera. [This] imagination must help us to live in the future so that we can indeed continue to live in the future' (Scholes, 1975, p16).

In practice, science fiction is the primary literary genre seeking to accomplish these goals (although Scholes and other critics would deny that all science fiction succeeds). In this visionary role, science fiction has served for decades as a non-academic form of communication in envisioning a wide array of alternate futures. Although there is much to criticize in the genre – including occasional lapses into forecasting – its continued vitality hints at the richness of future visions already existing in society. It provides an excellent example of an existing cultural resource that should be welcomed into policy debates on alternative futures.

Science fiction addresses themes relevant to debates on global futures, such as technology, environment and sociopolitical alternatives. Within the world of popular culture, science fiction has involved large numbers of people in a decades-long public dialogue (between authors and readers/fans) about the shape of possible future societies. This public conversation has utilized the power of the story form – a kind of power that the technical narrative of science lacks. By embracing fantasy, these stories achieve an imaginative range lacking in policy debates: they coax a suspension of disbelief, resulting in a creative expansion of the realm of the possible, and they demand emotional involvement. They are, therefore, able to access the multiple dimensions of personal and social experience and to provide an empathetic and holistic assessment of the possible future being envisioned.

Science fiction is, of course, only one of many potential contributors to an enriched global futures debate, within the realm of story, in a Western popular-culture context.

Conclusions

We have emphasized the social content of future visions and the processes of their creation, calling for the ongoing creation of multiple visions by a broad and diverse array of participants. We have argued in favour of multiple ways of knowing and of diverse expressive forms. We have not, however, addressed the politics of vision creation – how to ensure a diversity of views (diverse in both content and form) and how to achieve wide participation – or the politics of turning vision into action. These are, obviously, enormously problematic. To acknowledge the constraints on the creation of multiple, diverse visions (let alone their implementation) is, nevertheless, not to deny the validity of the visioning enterprise.

Currently, a newly globalized society is undergoing rapid political, economic and cultural shifts. Far from diminishing the validity of, or need for, social visions, chaotic times and conflicting values make them all the more necessary. By stimulating continuous broad-based discourse on alternative futures, the process of creating social visions offers choice and the chance to democratize thinking. The limited visions of alternative futures currently on the table need to be broadened in content to include any and all aspects of human life that various groups of people view as important. Employing multiple forms of expression or modes of discourse will bring not only richer visions but also wider participation and the recognition that envisioning is a dynamic process. In this endeavour, no vision is ever truly completed. There is no possibility of 'One Ultimate Vision'. This is in line with the emancipated and democratic risk analysis which this volume seeks: we believe that it is worthwhile to ponder goals and directions. Visions of the future offer a means to think through the consequences of current actions: there are stimuli for creativity and the sensing of possibilities, and tools for broadening the range and sharpening the terms of debate on possible global futures.

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