Published by the Sustainable Agriculture Programme of the International Institute for Environment and Development

Sustainable Agriculture in Britain: Recent Achievements and New Policy Challenges

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IIED

INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT

RESEARCH SERIES Volume 2, No. 1

SUSTAINABLE AGRICULTURE IN BRITAIN:

RECENT ACHIEVEMENTS AND NEW POLICY CHALLENGES

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1993

International Institute for Environment and Development
London

Research Series Volume 2, Number 1

The *Research Series* of the Sustainable Agriculture Programme of the International Institute for Environment and Development reports the findings of collaborative research carried out as part of the programme's activities. Each volume of the *Research Series* is devoted to a different research project.

This paper has been produced under the auspices of the *Policies for Resource Conserving Agriculture* research project of the Sustainable Agriculture Programme. This project is investigating the economic and environmental viability of alternatives to industrialised, conventional or Green Revolution agriculture in selected countries of the Third World, the UK and Europe, and the USA. It is drawing on cases of successful application of resource conserving practices and systems, elucidating the components of success, describing the factors currently limiting the spread, and developing policy frameworks to encourage alternative agriculture.

Published by the Sustainable Agriculture Programme, International Institute for Environment and Development, 3 Endsleigh St, London WC1H 0DD

1993

ACKNOWLEDGEMENTS

We are grateful to the following people for their advice, insights and suggestions during the research for this paper: John Bax, John Boardman, Paul Bowerman, Richard Clarke, Oliver Dowding, Caroline Drummond, Lindsay Easson, Clive Edwards, Bob Evans, Michael Fullen, David Gibbon, Irene Guijt, Vic Jordan, Bob Joyce, Nic Lampkin, Davy McCracken, Roderick McKinlay, Julie Noble, Lister Noble, Christopher Passmore, Keith Preston, Hugh Raven, Richard Sandbrook, Alistair Smith, Jeremy Sweet, John Thompson, Koy Thomson, Nigel Tichen, John Vipond, Drennan Watson, Charlie Wannop, Roger Young, and David Younie.

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Executive Summary

For some fifty years, British agricultural policy has actively encouraged farmers to produce more food. Farmers have been remarkably successful, using more external inputs to get high outputs of food. But narrow policy goals have brought hidden costs to farmers and the wider society. Now rural areas are characterised by widespread poverty and lack of economic opportunity, combined with growing concerns over damage to environmental resources.

This paper draws on emerging evidence from Britain, Third World countries and the USA to suggest that there exists an economically and environmentally viable alternative to both industrialised and organic agriculture. Such a sustainable agriculture pursues a more thorough integration of natural processes into the agricultural production process, combined with a reduction in the use of off-farm inputs, to achieve profitable and efficient production. It does not constitute a return to low technology or low output farming. It is not a single system of technologies and practices. It includes a wide spectrum of farming systems involving prudent use of pesticides, antibiotics and fertilizers. Conventional practices are not rejected, but the innovative resource-conserving practices are emphasised. These usually involve the substitution of labour, knowledge and management skills for the former high use of external inputs.

Until very recently, it was widely assumed that sustainable agricultural practices could only bring lower returns to farmers. They were thought to be 'low-input, low-output' practices. It is becoming increasingly clear, however, that integrated farms can match or better the gross margins of conventional farming, even though there is usually a yield per hectare reduction of some 5-10% for crops and 10-20% for livestock.

Detailed tables of evidence are presented to illustrate the yields and gross margins that have been achieved by a range of crop and livestock oriented initiatives. Profiles of integrated farms further illustrate the financial viability of sustainable agriculture.

Part of the problem, and a fundamental challenge, is that sustainable agriculture farmers cannot go it alone. Resource management that is both productive and sustainable requires all the users to work together for their common good. Such group action is a prerequisite for long-term success. It also becomes the mechanism for forging links between farmers and the wider rural community. Better information flows between all actors are component for an adaptive sustainable agriculture.

Sustainable agriculture creates new challenges for policy. It also articulates with increasingly important debates about sustainable development. These are being shaped by the agreements signed at the UN Conference on Environment and Development, and published in *Agenda 21*; in the EC 5th Environment Action programme *Towards Sustainability*; and the Department of the Environment's consultation paper published in July 1993 *UK Strategy for Sustainable Development*.

At present, however, policy gives support in only a very fragmented fashion. What is required is coordinated action to promote alternative practices that chart a middle ground between high- and no-external input agriculture to encourage adaptive and dynamic agricultural systems that are appropriate to local conditions. An 18 point agenda is presented that would encourage the adoption of resource conserving practices, support collective action at local level, and reform external agencies. With the appropriate policy framework, this should help to regenerate rural economies and environments.

Sustainable agriculture benefits farmers, rural communities, consumers and the environment. An extraordinary opportunity would be missed if more were not done to encourage its wider adoption.

GLOSSARY

ADAS	Agricultural Development Advisory Service
B	Barley
BSP	Beef Special Premium
BYDV	Barley Yellow Dwarf Virus
CAP	Common Agricultural Policy
CCP	Current Commercial Practice
CSS	Countryside Stewardship Scheme
ECU	European Currency Unit
EN	English Nature
EPA	Environmental Protection Act (1990)
ESA	Environmentally Sensitive Area
F&CGS	Farming and Conservation Grant Scheme
FMA	Fertilizer Manufacturers' Association
FW	Farmers Weekly
GM	Gross Margin
GPS	Global Positioning System
IPM	Integrated Pest Management
K	Potassium
LEAF	Linking Environment and Farming
LFA	Less Favoured Area
LIA	Low Input Approach
LU	Livestock Unit
LWG	Live Weight Gain
MAFF	Ministry of Agriculture, Fisheries and Food
MMB	Milk Marketing Board
MOPFF	Margin over Purchased Feed and Forage Costs
N	Nitrogen
NFU	National Farmers Union
NNR	National Nature Reserve
NSA	Nitrate Sensitive Area
P	Phosphorus
Po	Potatoes
PGR	Plant Growth Regulator
SAC	Scottish Agricultural College
SBe	Sugar Beet
SBn	Spring Beans
SO	Scottish Office
SOa	Spring Oats
SSSI	Site of Special Scientific Interest
SR	Stocking Rate
TGWU	Transport and General Workers Union
VC	Variable Costs
WB	Winter Barley
WGS	Woodland Grant Scheme
WOSR	Winter Oil Seed Rape
WOAD	Welsh Office Agriculture Department
WW	Winter Wheat

1. Rationale for Sustainable Agriculture in Britain

"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

1.1 The Pursuit of Productivity

Since the 1940s, farmers have been remarkably successful at increasing food production. They have intensified their use of resources to produce more from the same amount of land. Wheat yields have increased from an average of 2.1 to 7t/ha; barley from 2.1 to 5.9 t/ha; potatoes from 17 to 38 t/ha; and milk yields from about 11 pints per day to over 25 pints per day per cow (MAFF, MMB, *passim*). On the most productive farms, these averages may be almost doubled.

The success of this 20th century revolution lay in its simplicity. The principal aim has been increased productivity, and policy has been designed to pursue this goal. Financial support from the state, and later the European Commission, has been linked to output, and markets for produce have been guaranteed (Bowler, 1979; Bowers and Cheshire, 1983). This began in the 1940s when provisions were made under various Agriculture Acts for price subsidies of crop and livestock products, for grants for field drainage and other investment in fixed assets, and for subsidies of fertilizers and lime. The historic 1947 Act was a landmark, as it made as a principal objective the pressing need to raise food production and combat the chronic balance of payments deficit. Further provisions were made for ploughing grants, per capita payments for beef calves, hedgerow removal, and an annual price review procedure to set guaranteed prices that provided farmers *"at least a modest prosperity and insulation from economic factors"* (Bowers and Cheshire, 1983).

The 1952 Agriculture (Ploughing Grants) Act set two rates for ploughing up grassland, the higher of £30/ha (1952 prices) being for removal of at least 12 year old grassland. Rates of uptake of the grant were greatest in eastern and south-western counties where grassland was converted to cereal production (Bowler, 1979). The 1957 Farm Improvement Grant, which covered a third of the cost of improvements with a life of least 15 years, further favoured the development of capital intensive cereal and dairy farming, as land drainage and hedgerow removal qualified as well as buildings and machinery. These grants and subsidies continued through the 1960s, with further provisions to encourage the amalgamation of farms and the early retirement of farmers. It was not until after Britain entered the EC that many of these direct grants and subsidies were discontinued, such as for fertilizers and lime in 1974.

Farmers have, therefore, modernized by introducing machinery, replacing labour, specializing operations, and changing practices to ensure greater aggregate production. The pressure to increase economies of scale, by increasing field and farm size, has meant that the traditional mixed farm, a highly integrated system in which few external impacts are generated, has largely disappeared. Farms today are larger and fewer in number. Since

1945, the number of farms in England and Wales has declined from 363,000 to 184,000, while the total agricultural land has remained at about 19 million hectares (Marks, 1989; MAFF, *passim*).

By the 1980s, food commodities began to accumulate at an alarming rate in the European Community, producing the first food 'mountains'. The last decade has also coincided with growing recognition that this success in food production has brought with it hidden economic, environmental and social costs. The surpluses[1] absorb some 20% of the Common Agricultural Policy budget for storage alone. A further 28% is expended on export subsidies to keep the internal surpluses down, with considerable impacts on international food markets (CEC, 1991).

Less apparent are the environmental and social costs. The high level of food production has been bought at the expense of damage to natural resources and the destruction of rural communities.

1.2 Hidden Environmental Costs

The environmental problems caused by farming are a direct result of an increasingly intensive and specialized agriculture. The mixed farm is 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 and 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, such highly integrated systems have largely disappeared. Farms have become more specialized with crop and livestock enterprises separated. Livestock are often reared indoors on farms whose arable land is too small to provide sufficient uptake of the livestock wastes. Livestock enterprises have also become concentrated in well defined geographic regions, distant from the centres of arable cropping.

The intensification of agriculture has meant greater use of external inputs. But inputs of nutrients and pesticides are never used entirely efficiently by the receiving crops or livestock and, as a result, some are lost to the environment. Some 30-80% of nitrogen and up to 2% of pesticides are lost to the environment to contaminate water, food and fodder and the atmosphere (Conway and Pretty, 1991). As a result, natural resources may be damaged and people and wildlife harmed (Table 1.1).

[1] For example, at July 1993, there were the following surpluses: 29 million tonnes of cereals; 847,000 tonnes for beef; 5.5 million litres of wine; 560,000 tonnes of dried fruit; 177,000 tonnes of butter; and 57,000 tonnes of olive oil.

Table 1.1 The principal environmental and health problems caused by agricultural intensification in Britain (from Conway & Pretty, 1991)

CONTAMINANT / POLLUTANT	CONSEQUENCES
Contamination of water	
■ Pesticides	Contamination of rainfall, surface and groundwater, causing harm to wildlife and exceeding standards for drinking water
■ Nitrates	Methaemoglobinaemia in infants; possible cause of cancers
■ Nitrates, phosphates	Algal growth and eutrophication, causing taste problems, surface water obstruction, fish kills; and illness due to algal toxins
■ Soil	Disruption of water courses
■ Organic livestock wastes	Algal growth, plus deoxygenation of water and fish kills
■ Silage effluents	Deoxygenation of water and fish kills; nuisance
Contamination of food and fodder	
■ Pesticides	Pesticide residues in food
■ Nitrates	Increased nitrates in food; methaemoglobinaemia in livestock
■ Antibiotics	Antibiotic residues in meat
Contamination of farm and natural resources	
■ Pesticides	Harm to farmworkers and public; nuisance; harm to predator populations; harm to wildlife
■ Nitrates	Harm to wild plant communities
■ Ammonia from livestock	Disruption of plant communities; possible role in tree deaths
■ Soil and water run-off	Flooding on and off farm; damage to neighbouring housing and communities; nuisance
■ Metals from livestock wastes	Raised metal content in soils
■ Pathogens from livestock wastes	Harm to human and livestock health
Contamination of atmosphere	
■ Ammonia from livestock manures	Odour nuisance; plays role in acid rain production
■ Nitrous oxide from fertilizers	Plays role in ozone layer depletion and global climatic warming
■ Methane from livestock	Plays role in global climatic warming
■ Cereal straw burning	Nuisance; enhances localized ozone pollution of troposphere; plays small role in acid rain production, ozone layer depletion and global climatic warming
Indoor contamination	
■ Ammonia, hydrogen sulphide from livestock	Harm to farm worker and animal health; odour nuisance
■ Nitrogen dioxide in silos	Harm to farm worker health

It is widely recognised that pollution problems arising from agriculture have increased in recent years. Nitrate in water can give rise to the condition methaemoglobinaemia in infants, and is a possible cause of cancers. Pesticides contaminating water cause harm to 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 deaths and general nuisance to leisure users. Soil disrupts water courses, and runoff from eroded land causes flooding and damage to housing and natural resources. Pesticide and nitrate residues build up in foods. Various products threaten the farm and local natural resources, causing harm to farmworkers, the general public, plant communities and livestock. The atmospheric environment is contaminated by ammonia, nitrous oxide and methane derived from livestock manures, fertilizers and biomass burning. These costs to national economies and environments are growing, and are dispersed throughout many sectors the national economy.

There is still, of course, great controversy over many aspects of agricultural pollution (Conway and Pretty, 1991). DDT, long thought to be harmful to people as well as predatory birds, is now recognised as being safer than aspirin to humans. But, organophosphates used in sheep dips and believed to have little chronic toxicity are now the source of considerable debate as increasing numbers of farmers are reporting illnesses associated with dipping.

Nitrate in water is clearly harmful to humans in that it is converted to nitrite and gives rise to blue-baby syndrome in infants. Far more problematic is the role of fertilizer nitrogen in the production of cancers. In the laboratory and in human volunteers nitrate may be converted to nitrite, which is then combined with amines and amides to produce N-nitroso compounds that are known to be carcinogenic. However, the link between nitrate in the diet or drinking water and the incidence of gastric cancer has not been established epidemiologically. The known hazard of methaemoglobinaemia and the possibility of high nitrate concentrations resulting in human cancer have led to worldwide restrictions on nitrate levels in drinking water aimed to ensure they do not exceed 45-50 mg nitrate/litre (Conway and Pretty, 1991).

Some problems are declining. The number of reported pollution incidents of water courses arising from silage effluents, slurry stores and farmyard washings rose dramatically from some 1400 in 1979 to over 4000 by the end of the 1980s (NRA, 1990; WAA, 1986-89). These incidents have now fallen back to less than 3000 with the more coordinated support for farmers arising out of the issuing of Codes of Good Agricultural Practice by MAFF (MAFF, 1991, 1992), and the imposition of more severe fines for polluters. Under the Farm and Conservation Grants Scheme, grants have also been made available to assist in meeting the costs of combatting pollution (see Table 6.1: pages 49-50).

Soil erosion is one problem only recently recognised as being important. It too clearly illustrates the linkage between the pursuit of productivity and environmental damage. There was thought to be no problem from water erosion prior to the 1970s, but now it is recognised that 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, b). Since 1970, the land sown to winter cereals has tripled, largely at the expense of grassland and spring cereal. Erosion is now thought to be of the order of 30-95 t/ha in fields where field boundaries and hedges have been removed from critical positions. On the South Downs, for example, erosion was uncommon until winter cereals were widely grown. In the past ten years, loss of soil accompanied by flooding has caused many incidents of flooding of housing and farms, causing several million pounds worth of damage (Boardman, 1990, 1991; Boardman and Evans, 1991; Robinson and Blackman, 1990).

1.3 Rural Poverty

This period of remarkably successful agricultural growth has brought significant social change in rural areas (see eg, Newby, 1980). As farming has intensified its use of external inputs, so it has shed jobs, bringing severe poverty and deprivation to many people. Between 1945 and 1992, the number of regular hired and family workers on farms in England alone fell from 478,000 to 135,000[2] (MAFF, *passim*). In the past decade, there have been dramatic falls in the numbers of most classes of people engaged in farming activities throughout Britain (Table 1.2). The National Economic Development Council has forecast that the number of people engaged in agriculture will fall by a further 17-26% during the 1990s (in DoW, 1992).

Table 1.2 Changes in labour force (in thousands) on agricultural holdings in the UK, 1981-1992 (from MAFF Agricultural Statistics from Agricultural and Horticultural Censuses, prepared by Government Statistical Service, Guildford)

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

Where there were diverse and integrated farms employing local people, there are now operations specialising in one or two enterprises that largely rely on farm or contractor labour only. Where processing operations were local, now they are centralised 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 meant the steady decline in rural services, such as schools, shops, doctors and public transport. Although the number of rural people

[2] As statistics for all classes of people working on farms were not disaggregated in the 1940s, these figures do not include farm occupiers, wives/husbands, children at school, women's land army or prisoners of war.

in rural areas is increasing, the general view is that younger people tend to move out to be replaced by older, particularly retired, new entrants (DoW, 1992). More people want to move out too. A recent survey by the Henley Centre for Forecasting found that 76% of those who live in cities want to live in a village or country town (Rose, 1993). Another survey by Mintel found 37% of those in cities expecting to move out in the next decade. The rural community, bonded in the past by a common understanding and economic interest in the land, appears unlikely to be brought together by close links with farming.

Recent studies by an inquiry chaired by the Duke of Westminster, the House of Lords Select Committee on the European Communities, and the Archbishops' Commission on Rural Areas have shown that the incidence of rural poverty is considerable greater than previously supposed (DoW, 1992; HL, 1990; ACORA, 1990). According to an unpublished report commissioned by Department of the Environment, some 25% of rural households are living on or below the official poverty line (in DoW, 1992). According to the Office of Population and Census Surveys, 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 aged 15 to 44 years (in DoW, 1992). Farmers are increasingly recognised as suffering the stress and deteriorating confidence associated with lonely occupations (Martineau, 1993; Cornelius, 1993). As the Duke of Westminster's report recently put it:

> *"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"* (DoW, 1992).

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% to 48% (Ward, 1993). Succession is also less likely for farmers in the less prosperous areas (Marsden et al, 1992). Farming's declining economic fortunes seem to have eroded the commitment to successors in family farming. The prospect of a farming career appears to have become less attractive to farm children.

Rural culture in Britain would now appear to be as fragile as any in the poor countries of the Third World. In the quest for food production growth, landscapes have been homogenised and rural livelihoods and farming systems have been progressively simplified and standardised. Cultural diversity has fallen, leading to the fracturing of communities. Group and community-led initiatives have gradually been suffocated, resulting in the widespread loss of self-reliance.

1.4 An Opportunity for Sustainable Agriculture

Environment and development issues are increasingly shaping the concerns of government and non-government agencies, as well as farmers and consumers. Sustainable development, in its many forms, is now clearly articulated as a national policy goal following the 1992 UN Conference on Environment and Development in Rio, and the agreed document *Agenda 21*. The EC 5th Environment Action programme *Towards Sustainability* further sets out an environmental policy agenda, this time for an EC-wide context. And most recently, the Department of the Environment has published a consultation paper *UK Strategy for Sustainable Development*, in which the government states *"we are committed to a strategy for sustainable development"*. All of these will further articulate the hitherto hidden costs of agricultural development, and so exert more pressure for the reform of existing farm practices.

Coordinated action is clearly needed to revitalize rural communities whilst supporting a productive, sustainable and labour absorbing agricultural industry. Evidence is now growing that the result of such a regenerative strategy will be the creation of more productive and sustainable systems that emphasize the use of available resources, do not damage the environment and avoid the dependency on external and locally uncontrollable resources and systems. In addition, the adoption of such a strategy provides a mechanism to maintain existing farm employment and halt the continual decline in numbers of those employed directly on the land. It also offers the potential to promote wider employment opportunities off farm and hence contribute to revitalising the rural economy.

The tradition of sustainable and regenerative agriculture is well established in many countries of the Third World and the USA. In the UK, the evidence for the economic and environmental viability of regenerative agriculture, though weaker, is growing.

2. Sustainable Agriculture: Definitions and Misconceptions

"A farmer should live as though he were going to die tomorrow; but he should farm as though he were going to live for ever": East Anglian proverb (in Evans, 1966).

2.1 Internal Resources and Processes

Agricultural development policies have emphasised external inputs as the means to increase efficiency and effectiveness in pursuit of food production. For example, the national consumption of nitrogen fertilizer has increased from 0.15 to 1.3 million tonnes per year; and now individual cereal crops are treated some 5-7 times with pesticides, comprising 11-13 different active ingredients (FMA, *passim*; Jordan et al, 1993). These external inputs have, however, substituted for internal natural control processes and resources, rendering them less powerful.

Pesticides have replaced biological, cultural and mechanical methods for controlling pests and increasing predators; 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; and fossil fuels have substituted for locally generated energy sources (Table 2.1). The specialisation of agricultural production and associated decline of the mixed farm has also contributed to this situation. What were once valued internal resources have now become waste products.

The basic challenge for sustainable agriculture is to make better use of these internal resources. This can be done by minimizing the amount of external inputs used, by regenerating internal resources more effectively, or by combinations of both. A sustainable agriculture, therefore, is any system of food or fibre production that systematically pursues the following goals:

- A more thorough incorporation of natural processes such as nutrient cycles, nitrogen fixation, and pest-predator relationships into the agricultural production process;
- A reduction in the use of off-farm or external inputs with the greatest potential to harm the environment or the health of farmers and consumers and a more targeted and efficient use of the remaining inputs used;
- A greater productive use of the biological and genetic potential of plant and animal species;
- An improvement in the match between cropping patterns and the productive potential and physical limitations of agricultural lands to ensure the long-term sustainability of current production levels; and
- Profitable and efficient production with an emphasis on improved whole-farm management that is site-specific and which uses a systems approach to conserve soil, water, energy and biological resources.

Table 2.1 Internal and external resources for agroecosystems (adapted from Rodale, 1990, 1985)

	Internal resources and processes	**External resources and processes**
Sun	Main source of energy	Supplemented by fossil fuels
Water	Mainly rain and small irrigation schemes	Large dams, centralized distribution and deep wells
Nitrogen	Fixed from the air and recycled in soil organic matter	Primarily from inorganic fertilizer
Minerals	Released from soil reserves and recycled	Mined, processed and imported
Weed and pest control	Biological, cultural, mechanical and locally available chemicals	With pesticides
Energy	Some generated and collected on farm	Dependence on fossil fuel
Seed	Some produced on farm	All purchased
Management decisions and information on agroecological processes	By farmer and community - gathered locally and regularly	Some provided by input suppliers, researchers, extensionists - assumed to be similar across farms
Animals	Integrated on farm	Production at separate locations
Cropping system	Rotations and diversity	Monocropping
Varieties of plants	Thrive with lower fertility and moisture	Need high input levels to thrive
Labour	Labour requirement greater - work done by family living on farm and by hired labour	Labour requirement lower - most work done by hired labour
Capital	Initial source is family and community; any accumulation invested locally	Initial source is external indebtedness or equity; any accumulation leaves community

2.2 Terms and Definitions

There is no shortage of terms to categorise agricultural systems. They are defined with respect to current importance (favourable or marginal lands); to agricultural production ceilings (high or low potential lands); to technological concentration (Green Revolution or complex and diverse lands); to the quality of available natural resources (resource rich or resource poor); and to use of external inputs (high- or low-external input systems).

In addition, there are also different terms for the comparison of current conventional agriculture with alternatives. These include the terms alternative, regenerative, low-external input (LEI), low-input sustainable agriculture (LISA), resource-conserving, organic, biodynamic, and permaculture. Several of these are pitted in ideological terms against conventional, resource-degrading, industrialised, intensive, or high-external input (HEI) agriculture.

For the sake of simplicity, the term sustainable is mainly used in this report. It refers here to a loosely defined middle-ground between organic agriculture at one end of a spectrum, and high-input industrialised agriculture at the other end.

2.3 Misconceptions About Sustainable Agriculture

There are many misconceptions about low-input and regenerative agriculture (Pretty et al, 1991; Parr et al, 1990; NRC, 1989). Perhaps the most common is that low input farming represents a return to some form of low technology, 'backward' or traditional agricultural practices. This is simply not true. The hallmark of sustainable agriculture is not that the conventional practices have been rejected, but that innovative practices have been incorporated. Sustainable agriculture farmers commonly use modern equipment and technology, certified seed, complex rotation patterns, the latest innovations in reduced input strategies and new methods for livestock feeding and handling.

Another suggestion is that low- or no-input farming methods produce low levels of output, and so can only be supported by higher levels of subsidies. These subsidies are sometimes justified in terms of the positive benefits to environmental goods brought by sustainable farming, which could therefore be valued and paid for. But in the USA, in particular, and also increasingly in Britain, farmers can now show that their crop yields are close to or equal to those of their more conventional neighbours (NRC, 1989; Hanson et al, 1990; Dobbs et al, 1991). Even if their yields are lower, these may still translate into better net returns as their costs are also lower. This means that sustainable farming can be compatible with small or large farms, and with many different types of machinery.

A third misconception suggests that sustainable agriculture is something that can be precisely defined. A great deal of effort has gone into trying to define sustainability in absolute terms, and there are at least 75 different definitions for sustainable development. Such effort is misguided. The question of defining what we are trying to achieve with sustainable agriculture is part of the problem, as each individual has different objectives. It is neither a fixed set of practices or technologies, nor a model to describe or to impose on the world. For sustainable agriculture to prescribe a concretely defined set of technologies, practices or policies would be to close down on future options. As conditions change and as knowledge changes, so must farmers be allowed and encouraged to change and adapt too.

Another suggestion is that problems relating to agriculture should be defined before action is taken. But farming problems are always open to interpretation. All actors have uniquely different perspectives on what is a problem and what constitutes improvement in agriculture. Knowledge and understanding is socially constructed, and so what each of us knows and believes is a function of our own unique contexts and pasts. There is, therefore, no single 'correct' understanding. Where a single view prevails (in reductionist science, this is usually the scientific view), this is not because it is more 'correct', but because of the personality and power associated with the actor(s) proposing or promoting that view. Seeking multiple perspectives on problems is essential, and so there is a need for the wide involvement of different actors and groups. These multiple perspectives do not necessarily resolve to a single agreed position, and so may remain in conflict.

There are, therefore, always uncertainties, as the resolution of one problem leads to the development of another 'problem-situation'. The controlling paradigm of reductionist science ignores uncertainties, or else attempts to collect vast amounts of data to cover against uncertainty. The key feature then becomes the capacity of actors to learn continually about these changing conditions, so that they can act to transform existing activities. Those involved with sustainable agriculture must make uncertainties explicit and encourage rather than obstruct wider public debate about the dangers and benefits of pursuing different paths for agricultural development.

A final misconception is that sustainable agriculture is incompatible with existing farming methods. For the development of an alternative and sustainable agriculture, there is a need to move beyond the simplified thinking that pits industrialised agriculture against the organic movement, or the organic movement against all farmers who use external inputs. Sustainable agriculture represents an economically and environmentally viable option for all types of farmers, regardless of their farm location, and their skills, knowledge and personal motivation.

3. Economic Evidence for Integrated and Sustainable Agriculture

"These improvements would impart financial benefits, besides it would add to the beauty of the prospects from the house": Mr. Brolter, Suffolk farm advisor and valuer, 1790.

3.1 Integrated Farming

Sustainable agriculture involves the integrated use of a selection of pest, nutrient, soil and water management technologies and practices. Most represent low-external input options. They are usually integrated on farms to give a finely-tuned strategy specific to the biophysical and socioeconomic conditions of individual farmers. The principle is thus increased diversity of components within farms combined with increased linkages and flows between them. By-products or wastes from one component or enterprise become inputs to another. Natural processes increasingly substitute for external inputs, and so the impact on the environment is reduced.

3.2 Evidence from the Third World

There is growing evidence that the adoption of regenerative and low-external input 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, unlike Britain and Europe, the emerging concern is to increase food production in the areas where practices have been largely untouched by the modern packages of external inputs and technologies. There is, however, a great deal that British farming can learn from these successes.

In the complex, marginal and remote lands of the Third World, farmers adopting regenerative technologies have doubled or trebled crop yields, often with few or no external inputs (Bunch, 1991; Shah, 1992; Pretty et al, 1991; Chambers et al, 1989; Conway and Pretty, 1991; Reijntjes et al, 1992; UNDP; 1992; Pretty and Chambers, 1993). In the high-input, generally irrigated, Green Revolution lands, farmers adopting regenerative technologies have maintained yields whilst substantially reducing inputs (Winarto, 1992). These improvements have been in programmes focusing on soil and water conservation, land rehabilitation, nutrient conservation, raised field agriculture, green manuring, and integrated pest management.

Such yield improvement through sustainable intensification using internal resources has been accompanied by further indirect economic benefits. There is less need for expansion into non-agricultural areas, so ensuring that non-agricultural plant and animal species with value to local people will be sustained. Non-use benefits are also preserved, such as locally valued cultural sites and globally-valued diverse ecosystems, both of which are threatened when cultivation expands. There is reduced contamination and pollution of the environment, so reducing the costs incurred by farming households, consumers of food, and national economies as a whole. Migration patterns can also be reversed as economic growth within communities occurs as the demand for labour grows.

This evidence shows that regenerative agriculture is possible, and can have wider benefits. It does not alone indicate how it may be adopted in the UK. However, all successes have had four elements, and these provide institutional lessons for the British context. All have made use of resource conserving technologies. In all there has been action by groups or communities at the local level. And there have been supportive external government or non-government institutions.

Most, though, are still localised. This is because the fourth element, an enabling policy environment, is missing. Most policy frameworks still strongly encourage farming that relies on external inputs and technologies.

Some still argue vigorously that modern agriculture, characterised by externally generated packages of technologies that rely on externally produced inputs, is the only path for agricultural development. Indeed, the Nobel laureate, Norman Borlaug, has recently stated that *"the adoption of science-based agricultural technologies is crucial to slowing - and even reversing - Africa's environmental meltdown... Development specialists ... must stop 'romanticizing' the virtues of traditional agriculture in the Third World. Moreover, leaders in developing countries must not be duped into believing that future food requirements can be met through continuing reliance on ... the new complicated and sophisticated 'low-input, low-output' technologies that are impractical for the farmers to adopt"* (Borlaug, 1992).

It would appear that, despite the growing evidence, it is still common for many to assume that sustainable agriculture represents a low output type of agriculture, and so should not be widely promoted.

3.3 Evidence from the USA

Further evidence to support the economic success of regenerative agriculture comes from the USA, where relatively well developed policies, combined with considerable research effort and state financial support, are being translated into new productive practices by farmers. It is widely recognised that the economic performance of regenerative agriculture, commonly called LISA (low-input/sustainable agriculture) or alternative agriculture, can regularly match or better neighbouring conventional farms (Lockeretz et al, 1984; Liebhart et al, 1989; Batie and Taylor, 1989; NRC, 1989; Faeth et al, 1991; Hanson et al, 1990; Dobbs et al, 1991; Madden and Dobbs, 1991; Munn, 1991). But as conventional yield levels are already lower than in the UK, resulting from lower use of inputs, these have been easier to match.

Sustainable agriculture in the USA is now well established as a viable alternative to both organic farming that relies on premiums and industrialised farming that relies heavily on external inputs. No such viable middle ground has yet been charted in Britain.

3.4 Evidence from Britain and Europe

In the UK, and other countries of northern Europe, where agriculture already makes more intensive use of external inputs, the challenges are rather different. The fact that average wheat yields are some 7t/ha[3], more than three times those in the USA, means that farmers have a particular problem matching yields and/or gross margins. Comparative studies have hitherto explored the differing performances of conventional and organic farming practices. Many of these studies appear to show that organic farming is unable to compete with conventional farming under the current structure of subsidies and support (eg Lampkin, 1992; Rhône-Poulenc, 1992, 1993). Many argue that organic agriculture should receive direct support to compensate for lower cereal and livestock yields. This would put an economic value on the environmental damage not caused by organic farming.

However, none of these studies adequately represents the potential for a regenerative or sustainable agriculture that is positioned somewhere between organic and high input agriculture, and so is available to all British farmers. The limitation for organic agriculture is that it is to a certain extent a positional good[4]. Organic farmers rely on the premium consumers are willing to pay, yet if the number of organic farmers increases above a certain ceiling, then premiums are likely to fall. There is evidence of this happening in Denmark, where the government introduced payments, combined with tough new pollution legislation, to encourage farmers to convert to organic practices (FW, 1992a). In four years the area under organic management increased from 5900 to 17900 ha, but this expansion has led to falling prices, as consumers have not been willing to pay the higher prices in sufficient numbers.

There is, however, growing economic evidence to indicate that farmers can reduce external input use significantly without losing out on gross margins. Through the adoption of resource conserving technologies, yields and variable costs fall, and so gross margins can be matched or bettered[5] (see Tables 3.1 and 3.2: pages 18-21). This evidence is quite remarkable. Until recently, most farmers, researchers and policy makers assumed that although resource conserving practices might be environmentally beneficial, the reduction in gross output would inevitably mean reduced profitability. It is increasingly clear that this is not the case.

Table 3.1 summarises crop results from both research initiatives and working farms. These include the LIFE research project coordinated from Long Ashton Research Station, which

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[3] Top yields of 13 t/ha for wheat have been reached in the south east of England, and many farmers commonly report yields of 10 t/ha.

[4] Fred Hirsh has described a positional good as one in which there is a brief period when something, here the organic premium, is enjoyed by a fortunate few. When the benefit becomes more widely available, its nature changes (such as when one person stands on tiptoe, he or she gets a better view; but when everybody does, nobody can see).

[5] There are also methodological issues that are important to consider when making these kinds of comparisons. First, these tables are not intended to be comprehensive. They do not represent randomly sampled data, and so do not illustrate what the average farmer has been achieving. Rather, they show what is possible, given appropriate knowledge, skill and motivation. Second, it is practically impossible to control for a range of factors when making these comparisons. These factors include breed and varietal differences; soil, climatic and topographical differences; experience, ability and motivational differences in farmers; farm size, layout and tenurial status; and marketing and processing opportunities. Third, gross margins can be misleading, as integrated farming is dependent on the interactions between components of the system, and so the best results may only be achieved occasionally. Long periods are, therefore, needed for comprehensive comparisons, so that full rotations are completed.

is comparing integrated and conventional rotations with standard practice; low-input sugar beet trials at Broom's Barn Experimental Station; the Talisman project, drawing from results from Drayton and High Mowthorpe; reduced fungicide experiments at Scottish Agricultural College; reduced pesticide regimes on the Boxworth project; and the Nagele and Lautenbach integrated farming research initiatives in the Netherlands and Germany.

These results indicate that crop yields under the integrated or sustainable regimes reach 78-105% of the conventional comparisons[6]. Most are of the order of 5-10% less. The gross margins are almost all higher than the conventional comparisons, ranging from 1% lower to 3-52% greater.

Data is also presented from a range of comparisons between organic and biodynamic farms and conventional equivalents in the UK, Germany and Switzerland. Much of the data for gross margins includes the premium received for organic produce.

Table 3.2 summarises the results from comparisons between dairy, beef and sheep raising on low-input grass-clover pastures with high nitrogen grasslands. Yields of milk and meat on the SAC farms at Bush Estate, Craibstone, and Crichton Royal are very close to the conventional comparisons. But this still translates into lower gross margins per hectare as the livestock on less intensive systems are stocked at considerably lower rates per hectare. The data for fully organic dairy herds show lower yields compensated when it comes to gross margins by the premiums on organic milk.

But this data only partially describes the benefits brought by integrated farming. There are also indirect benefits of value to farmers, ecosystems and the public and society as a whole. These include better quality of products, such as better tasting beef and lamb (Younie et al, 1990; SAC, 1992); the amenity value associated with more diverse and wildlife-rich landscapes; the maintenance of environmental quality, such as uncontaminated aquifers and surface water; the sustaining of resources for future generations; increased bird populations and territories (Gremaud and Dahlgren, 1982; Youngberg et al, 1984; Wilson, 1992); reduced soil erosion (Reganold et al, 1987); increased numbers of beneficial insects (Elsen, 1989; Dritschilo & Wanner, 1980; Wratten, 1992; Game Conservancy, 1993); and less stressful livestock as a result of lower stocking rates and non-routine use of drugs.

Four detailed profiles of integrated farms are presented to illustrate how farmers in very different conditions have put into practice some of the principles of sustainable agriculture (Boxes 3.1 - 3.4: pages 22-25). All are profitable enterprises, and all produce significant environmental benefits. Only one eschews the use of external inputs entirely. The four profiles are of a 500 ha arable farm in Norfolk, a 344 ha mixed livestock and arable enterprise in West Sussex, a small dairy research farm in Dumfries, and a 371 ha mixed dairy and crop organic farm in Somerset. Once again, these are not intended to represent a comprehensive picture of British sustainable agriculture. Rather they are included to give a flavour of what can be achieved.

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[6]The yield 'penalty' indicated in these results is only a problem if it is viewed from the perspective of needing to maximise food output. This is, of course, not now the case. As EC and individual state policies are now targeted to reduce output through the use of the set-aside mechanism, this yield penalty could now be seen as a benefit.

These economic indicators suggest that large scale change in the UK might be possible. They are important because they are more likely to influence farmers' decisions to adopt new regenerative practices. One recent survey of farmers found that although 69% supported the move to less intensive integrated farming, some 90% said the motivation to change depended on economic advantage (Jordan, 1993). This evidence suggests there is economic advantage in sustainable agriculture. However, it is still very thin. Much of it is derived from the controlled conditions on research stations. There is clearly a need for more research, particularly studies of individual farms and farmers.

All of the successes in Tables 3.1 and 3.2, together with those referred to from the Third World and the USA, involve the substitution of information and labour for external resources. Farmers have to engage in more regular and sequential sampling of pest and weed levels within fields, such as by field walking. Sampling of soils and laboratory analyses are necessary to give information on nutrient levels, allowing careful nutrient management. Wild plants have to be managed to encourage particular predators, and hedgerows and woodlands maintained. And more labour may also be required for hand weeding, maintenance of fencing, upkeep of soil and water conservation measures, and so on. This could mean that sustainable agriculture represents the opportunities for farming to be productive, sustainable and labour absorbing. However, as we shall suggest later, it will also need coordinated action by businesses in the community to build on these opportunities.

Table 3.1 Economic indicators for performance of crop components and complete farms of sustainable agriculture in UK and Europe as proportion (%) compared with conventional

Description	*Crop yields*	*Input Use*	*Variable Costs*	*Gross Margins*	*Comments*
Integrated rotation: less intensive regime compared with standard practice, UK (1)	89%	10-81%	64%	103%	Input use 10% for insecticides; 81% for herbicides; 69% for N
Conventional rotation: less intensive regime compared with standard practice, UK (1)	92%	19-100%	68%	116%	Input use unaffected for insecticides; 81% for herbicides; 71% for N and zero for PGR
Sugar beet: comparison maximum yield and 'environmentally benign' production systems; yields adjusted to sugar concentration of 16%, UK (2)	78%	n.d.	60%	102%	Gross margins greater when quota system applied
Talisman Project (reduced input): alternative rotation low input approach (LIA) compared with current commercial practice (CCP) (Drayton) UK (3)	SBn 88% SO 105%	0-50% 50%	n.d. n.d	96% 112%	Input use 50% for fungicides and zero for insecticides and herbicides. Inputs of pesticides and nitrogen cut by 50%
Talisman Project (High Mowthorpe): standard rotation LIA compared with CCP, winter beans, UK (3)	99.6%	0-50%	n.d.	101%	Input use 50% for fungicide and zero for insecticide
Reduced fungicide use on spring barley, Scotland (4)	102%	12-25%	n.d.	126-152%	2 full rate applications compared to 2 quarter rate mixed applications on three SB varieties
Boxworth Project (reduced pesticides): high input full dose compared with 'supervised' lower input, UK (5)	WW 88% WOSR 105%	15-54% 0-96%	66% 66%	105% 139%	For WW herbicides 54%, fungicides 59% and insecticides 15%. For WOSR herbicides 96%, fungicides 3% and insecticides zero, all based on cost.
Integrated farm, Netherlands (6)	94%	26-50%	86%	120%	Input use 26% for nitrogen; 30% for pesticide active ingredient; 50% for number of applications
Boarded Barns organic farm trials, UK (7)	W 72%	54% cost (organic fertilizer & sprays)	91%	91%* 55%	Variable costs high because high price of imported pelleted chicken manures. Mildew controlled with sulphur and aphids with liquid derris

Wookey organic farm (8)	60%	zero	48%	119%* 79%	1983 & 1984 12 WW crops on one farm
Switzerland 26 organic farms (9)	W 86% B 86% Po 103%	zero zero zero	71% 51% 68%	115%* 108%* 116%	GM for wheat includes premium of 12.5%, and for barley 5%; no premium on potatoes
Germany biodynamic farms, data for cereal production (10)	75-91%	zero	63-86%	95-141%* 80-101%	Farms in Baden-Württemburg
Switzerland 8 biodynamic farms (11)	95-100%	zero	-	100%	Premium obtained only for wheat, not for potatoes, dairy and forage; extra labour required (110-115%)
Individual organic and 'semi organic' farms, results for WW, UK (12)	53-114%	zero	24-75%	57-138%	GMs are without premiums
Switzerland, 57 organic & 72 conventional farms, 3 year study 1986-88 (13)	73%	F 22%[1] P 6%	47%	112%* 83%	Observations for WW production from paired farms
Germany, whole mixed farm comparison, various results organic and conventional 1986-1991 (14)	W 66% Rye 67% Po 61%	F 3%[1] P 6%	99%	105%/ha 110%/ farm	Study compared physical and financial results, extracts are averages for between 183-879 farms over 6 yrs
Germany, Lautenbach integrated and conventional farm (15)	W 99% SBe105% All 99%	75%	70-90%	W 109% SBe108% All 104%	8 years of data; nitrate leaching lower; reduced cereal diseases; more soil biota; greater diversity of predators in hedges & fields; no insecticides used

Note: where a value is 100%, this means that the yield, input use, variable costs or gross margins are the same for both the sustainable agriculture and conventional agriculture. A value of 116% in the gross margins column means that the sustainable agriculture outperforms the conventional by 16%. A value of 89% in the yield column means that the sustainable agriculture yields 11% less than the conventional comparison.

* = gross margin with organic premium.
n.d. = no data
[1] % of conventional cost on fertilizer (F) and pesticides (P). Quantities or usage volumes not available.

Sources: (1) Jordan et al, 1993; Jordan, 1993; (2) Jaggard, 1993; (3) Ogilvy, 1993; (4) Wale, 1993; (5) Greig-Smith et al, 1993; (6) Vereijken, 1990; (7) Rhone-Poulenc, 1993; (8) Wookey, 1987; (9) Steinmann, 1983; (10) MELU, 1977; (11) Karch-Türler, 1983, in Lampkin, 1990; (12) Vine & Bateman, 1983; (13) Muehlebach & Naef in Lampkin, 1992; (14) BMELF, in Lampkin, 1992; (15) El Titi & Landes, 1990; Zeddies et al, 1986.

Table 3.2 Economic indicators for performance of livestock component of regenerative agriculture in UK and Europe as proportion (%) compared with conventional

Description	*Yields (kg milk or meat per animal)*	*Variable costs*	*Gross margins per animal*	*Gross margins per hectare*	*Comments*
Organic beef, Scotland (1) Comparison of organic grass/white clover system with a conventional, intensively fertilized system (270 kg N/ha/yr)[1]	100% slaughter weight	107% (per head)	100% 131%*	76% 101%*	Lower stocking rate of organic animals (3.42 to 4.46 LU/ha) resulted in a 23% lower LWG/ha. Average price premium of 14% resulted in comparable GM/ha and 31% higher GM/animal. VCs higher as fed organic cereals plus milkpowder in winter.
Sheep on white clover pastures with no N, compared with 150-180 kg N/ha/yr grass systems Scotland (2)	122% (ave LWG 4 yr trial)	n.d.	n.d.	95% & 106% [I]	No nitrogen added to clover-ryegrass pastures; 22% lower stocking rate on clover system resulted in a comparable output due to higher (20%) individual animal performance.
Organic milk herds, UK (3)	92%	116%	111%* 98%	89%* 79%	Concentrate use 79% of conventional; stocking rates 1.79 compared with 2.22.
Alternative dairy, Germany (4)	83%	72%	86%	75%	Concentrate use 28% of conventional; cows in alternative herd more fertile and live longer.
Organic dairy, 26 farms, Switzerland (5)	88%	93%	98%*	90%*	Gross margin per animal excludes forage.
Biodynamic dairy, Germany (6)	64%	64%	113%*	69%*	Variable costs exclude forage.
Low input (no inorganic N) grass/clover diary production compared with high N input system (350 kg N/ha/yr), Scotland (7)	99.8% milk sales, litres per cow	n.d.	90%	90[2]	In year 3 of the study stocking rate for clover system reduced to 1.9 LU/ha by increasing the land area. Despite GM/ha declining to 82%, overall surplus £1200 higher on clover unit. MOPFF in year 3 was £37/cow higher on the clover system.

* = gross margins with organic premiums
n.d. = no data
See next page for notes on this table.

[1] Represents 4 year average LWG/ha of sheep on clover-grass mix compared with tetraploid and diploid grass systems. This appears to be a reasonable approximation to margins since the system is low input, not organic, and therefore no premiums are available.

[2] Average of first two years of study only when both herds managed at same stocking rate (2.4 LU/ha) on the same area.

Sources: (1) Younie, 1992, FW 1993a; (2) Vipond et al, 1992; (3) Redman, 1992; (4) Gravert et al, 1992; (5) Steinmann, 1983; (6) Jochimson, 1982, in Lampkin, 1990; (7) Bax and Fisher, 1993; Bax, 1992

Box 3.1 Profile of Carbrooke Hall Estate, Watton, Norfolk
512 ha arable farm (490 ha arable & 22 ha woodland).

Crops: The rotation, typical for this part of East Anglia, is a mixture of wheat, break crops and sugar beet. Wheat is grown once in each rotation, and always after the break crops of oilseed rape, protein peas and protein beans. Sugar beet harvested before December is also followed by winter wheat; but spring wheat, drilled in December follows the late lifted beet. Set aside, which can be considered a compulsory crop, has now replaced winter barley, the least profitable crop of the previous rotation. Approximately 50 ha are in set aside. Growing for the best profit has meant, in the past, seeking the best yields, which for wheat has meant growing only after break crops or sugar beet, with no second or continuous wheats.

Average crop yields have been as follows: winter wheat 9 t/ha (feed) and 8 t/ha (milling); winter barley 5-6.5 t/ha; protein peas 4 t/ha; winter oil seed rape 3-3.5 t/ha; spring wheat 7.8 t/ha; spring barley 5.5 t/ha; sugar beet 50-55 t/ha; and linseed 3.1 t/ha.

Weed, insect & disease control: The farm operates a 'managed input system', and so relies on regular field monitoring and crop inspections to determine the level of inputs required. Detailed knowledge of the various weed species, assessment of weed numbers and identification of growth stages or the level and type of aphid infestation, together with forecast weather conditions, are used to determine whether full dose, reduced dose or no applications are required.

Natural predators are encouraged by the management of field boundaries and the maintenance of a number of grass strips around certain fields. If 2m wide field margins could count towards the farm's set aside requirement, the farm manager would consider the use of *Phacelia* strips around most fields. Protection of natural predator populations is also encouraged by the use of the more expensive, but target specific, insecticides such as Aphox.

The farm manager has also developed a unique approach to control the farm's large pigeon population. As pigeons associate people with cars, a number of rusting wrecks have been placed in fields around the farm. Whilst driving around the farm, he uses a Very pistol to fire bangers into the flocks, thereby increasing their association of danger with cars. This has proved an effective deterrent, is cheap and is popular with the local community, who are no longer forced to endure repeated blasts from the six, now abandoned, propane gas guns. Reduced herbicide spraying on sugar beet has been achieved by a more targeted approach to spray applications. Overall spraying has been replaced by using a twelve-row band sprayer which covers only the nine inches straddling each row, the area between rows is kept weed free by using a twelve-row hoe.

Soil fertility: Nitrogen fertilizer is applied on a 'little and often' basis. Quantity is matched to each crop's ability to take up what is spread. Wheat always follows on from peas. The residual pea root action persists, providing a certain amount of nitrogen for the wheat, which in turn requires less applied nitrogen. Applications on good land are typically between 200 and 220 kg N/ha/yr. The whole arable acreage is also subsoiled in a three year cycle to reduce compaction in the lower levels and hence improve soil conditions. All fields are soil tested every four years.

Environmental management: Ancient Norfolk 'A' shaped hedges mark out field boundaries and are currently managed by trimming rotationally, three years in five, and replanting gaps with white and black thorn hedging or with trees, usually oak. All woodlands are subject to a programme of thinning or felling and then replanting. Some 80% of the trees are hardwoods with oak accounting for 70% of all trees. Over the last five years, 800 trees have been planted either as individuals or in small groups. Better sited ponds have recently been cleaned to their original depth and are being left to settle to allow recolonisation.

Source: Roger Young

Box 3.2 Profile of Applesham Farm, Coombes, West Sussex
344 ha mixed livestock and arable enterprise.

Crops: The crop rotation is winter wheat/ winter wheat/ spring barley (undersown)/ grass-clover ley/ grass-clover ley/ grass-clover ley. Catch crops of Italian ryegrass, mustard and forage rape are slotted in where possible to provide additional stock grazing. In 1992/93: 83 ha of winter wheat, average yield 7.2 t/ha; 71 ha of spring barley, average yield 6.3 t/ha; 7 ha forage rape; 70 ha grass/clover ley; 74 ha permanent pasture and 27 ha set aside.

Livestock: 100-head suckler herd, comprising both Freisian x Hereford and 30 pedigree Limousin cows, and a flock of 400 breeding ewes. The cows are overwintered on the leys and the Downland bank. Lambing occurs in April in outside corrals formed from big round straw bales.

Weed, insect and disease control: The farming system encourages predator populations by undersowing the last cereal crop in the rotation, usually spring barley, with a grass-clover ley mixture. This provides an ideal habitat for predatory insects to overwinter, as well as a rich food source for the farm's indigenous grey partridge population. Economic thresholds for aphids are only occasionally reached during the summer, and so insecticides that may threaten indigenous aphid predators have not been used in recent years.

Soil fertility: By incorporating a large proportion of white clover, up to 50% in the ley mixtures, the pasture provides a relatively low cost, high quality diet for livestock throughout summer. The build up of soil nitrogen reserves also means that relatively low rates of nitrogen are used on the cereals, particularly in the first two years.

Environmental management: For wildlife corridors, rough grassy banks are allowed to flourish along fence lines, and 5-10m wide fenced grass headland provides a stock trail and favourable wildlife habitat. Downland bank management: *although the 1700 m escarpment is maintained in an unimproved state,* it does contribute to the cropping rotation of the farm. When surrounding fields are down to leys it is grazed year-round for three years, so keeping coarse grasses and scrub invasion in check. When surrounding fields are down to cereals, the lack of summer grazing allows wild flowers and grasses to bloom and replenish the seed stock. The bank is then grazed for a short period between harvest and autumn ploughing which removes excess vegetation. Over the past few years, more than 140 different species of broad-leaved plants and 21 different butterfly species have been recorded on this bank.

This 28 ha bank is entered into Tier 1 of the ESA scheme (for maintaining existing chalk downland). Another 35 ha of steeper, less fertile land has been converted from arable production to *chalk downs,* and is also under the ESA scheme. Approximately 20% of the farm now in the scheme. Several ponds have been renovated and created, and more than 1000 trees have been planted in recent years.

Source: Christopher Passmore and LEAF

Box 3.3 Profile of Crichton Royal Farm, Dumfries, Scotland

The Crichton Royal Farm is operated as a dairy and grassland research farm, for the Scottish Agricultural College (SAC), as part of the Grassland and Ruminant Science Department.

Crops and livestock: The farm extends to 253 ha and rises from sea level to 75 metres above sea level. The predominant soil type is sandy loam with areas of silty clay. Annual rainfall is 1023 mm. There are currently 350 dairy cows and their replacement youngstock plus a beef fattening unit. The dairy cattle are used for both systems studies and for more detailed grazing and feeding experiments. There is also a small arable enterprise of 32.5 ha. The cropping details are 13 ha of spring barley, 8 ha of winter barley, 4 ha of forage maize, 3 ha of fodder beet and 4 ha of set-aside.

Nutrient management and weed, insect and disease control: Farming practice has also been altered to reduce its environmental impact. A pumped umbilical slurry spreading system was purchased which enables more efficient use to be made of the nutrient value of animal wastes. Operating at lower pressures than traditional vacuum tankers it also reduces the odour and ammonia nitrogen emissions. All black polythene sheeting is now recycled and sisal baler twine has been re-introduced. When inorganic fertiliser is applied care is taken to avoid spreading into hedgerow bottoms. Extensive use is made of disease resistant cereal varieties and spraying is kept to a minimum. Using a tramline system no spraying is carried out for 3 m out from the headlands. The forage maize, fodder beet and some of the barley is grown using only slurry as the nutrient source.

Research at the Crichton Royal Farm is also being directed towards developing systems that reduce the losses of nutrient and energy in dairy production. One long term study is investigating the potential for white clover based extensive systems for milk production, and there are currently 56 ha of clover rich swards on the farm. These receive no inorganic nitrogen fertilizer, relying instead on the nitrogen-fixing capability of white clover. The use of herbs and flower-rich extensive meadows is being investigated in another project which aims to develop a viable heifer rearing enterprise on botanically diverse swards. The changes made in recent years have demonstrated that it is possible to integrate profitable dairy farming systems with improving the environment.

Environmental Management: although the Crichton Royal Farm is operated as an intensive dairy farm, considerable emphasis is placed upon maintaining, and improving where possible, the environmental value of the land. Woodland, hedgerows, wetlands and conservation areas now cover 9.6 ha. In 1987/88 a new 2.8 ha plantation was established under the Broadleaved Woodland Grant Scheme following a period of replacing old and diseased hedgerow trees. In all, approximately, 4000 trees were planted. The management of the hedgerows has been altered, cutting kept to a minimum and cutting itself delayed until February to preserve the berries. Recently a completely new hedge of 220 m in length was planted. In a low lying area of the farm it was possible to create a 1.5 ha wetland area. The tracksides within the farm are no longer cut or sprayed, and together with the bankings and waste areas are left to create additional wildlife corridors.

Source: John Bax

Box 3.4 Profile of Hill Farmhouse, Shepton Montague, Somerset
371 ha organic dairy and arable farm. Conversion to organic status began in 1989 to Soil Association standards. The last three fields will complete conversion in 1994 and the dairy herds achieved Symbol status on 1st October 1992. As Oliver Dowding put it: *"All told, our organic management has not presented as many disasters as we feared, and many bonuses"*.

Livestock and crops: There are two dairy herds of 120 and 190 cows producing about 1.75 million litres of milk each year. Other livestock are 70-80 calves reared each year as dairy herd replacements to calve at 2-2½ years old, and 40 beef cattle. The farm grows 80 hectares of cereals, mostly wheat but with some barley and oats. Oliver Dowding has seven full-time and two part-time employees.

Since 1st January 1993, about 60% of the milk has been going to make Symbol cheddar cheese for the Farmers' Dairy Company. The cereals are sold according to quality and demand. This (1993) harvest has produced the most pleasing yield and visually attractive sample yet. However, in common with many producers, organic and conventional, quality (protein and milling ability) have been low. Oats are partly grown on contract to make Duchy Original biscuits. Yields of oats were 3.7 - 5 tonnes/ha, wheat 4.4 - 5.9 t/ha, and winter barley 4.7 t/ha.

Grass is the farm's main crop. Most is white clover and ryegrass. This yields well, and production is reasonably consistent throughout the year, reducing the peaks and troughs associated with fertilized pure-ryegrass leys. Red clover-ryegrass is the most productive forage grown, but limited by not being grazeable as it causes bloat very easily. It has consistently yielded 44-50 t/ha of fresh grass at 20% dry matter. Lucerne mixed with ryegrass is similarly productive.

Weed, insect and disease control: The greatest threat is from docks. A considerable sum is spent on employing casual labour to strim or pull docks round the fields and buildings as well as in the crops. This is to prevent build up of seed banks. This has the added spin-off of providing local people with work. Other weed control is mechanical. Thistles are topped and die. Weeds in the cereals are extracted, or suppressed enough to stop seeding, by a harrow comb used in the growing crop according to need. This may pass over the crop from 0-3 times, and is very efficient, only struggling with wild oats, docks and some grass weeds. Disease in cereals is suppressed through choosing disease-resistant varieties. Insect attack has been rare, perhaps aided by the smaller than average fields (only six are over 8 ha).

The livestock are treated for illness with homeopathic remedies. They do receive some antibiotics or non-organic drugs when the severity demands it, and then considerably longer withdrawal periods have to be observed before milk and meat can be sold. The use of homeopathy was originally a daunting prospect for the herdsmen, but they are now happy with it. The use of conventional drugs is now rare.

Soil fertility: Dung and farm-yard manure is spread during the summer months, and all onto grassland that has either been cut or needs extra 'fertilizing'. It is applied at this time because the ground is warm and the earthworms are active enough to incorporate it. Over wintered stubbles are all planted with a mustard crop to hold any residual free nitrogen and to help build organic matter. This also a good way of suppressing weeds.

Environmental management: Three hedges of some 1,100 metres length have been planted over the past five years. More will be planted, but they will also be removed where they have become ragged or are dividing up very small pieces of land. Farm management is realistic, and so accepts that the loss through reduced management ability and weed ingress sometimes means removing a hedge. New planting ensures a thriving balance. Two hectares of poplar have been felled and replanted (plus one extra hectare) to hardwoods. An over-mature oak, ash, beech and yew copse of one hectare has also been felled. This has been replanted to the same mix of species. Other woodland is thinned and managed to produce the maximum useable timber. About 1,000 new trees have also been planted as part of an programme to boost timber output and wildlife habitats.
Source: Oliver Dowding

4. Resource Conserving Technologies and Practices

"Wise husbandry goes hand in hand with environmental good": Royal Commission on Environmental Pollution, 1979

4.1 Introduction

This chapter gives details of proven and promising resource conserving technologies and practices in the areas of pest control and nutrient management. These draw on a range of experiences from both farms and research stations, where the impacts of pests, diseases and weeds have been reduced; the viability of natural predators enhanced; the efficiency of pesticide and fertilizer use improved; and nutrients and soil conserved. Many of these are examples of farmers already taking steps to reduce costs and the adverse environmental effects of their operations. Some have done so by improving conventional practices; others by adopting alternatives. Most have tried to take greater advantage of natural processes and beneficial on-farm interactions, so reducing off-farm input use and improving the efficiency of their operations.

Many of the individual technologies are also multi-functional. This implies that their adoption will mean favourable changes in several components of a farming system at the same time. For example, hedgerows 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. 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.

Integrated pest management (IPM), for example, is the integrated use of some or all of the pest control strategies in a way that not only reduces pest populations to satisfactory levels but is sustainable and non-polluting. Similarly, integrated nutrient conservation is the coordinated use of a range of practices to ensure appropriate local nutrient management. Inevitably these are more complex processes than, say, relying on regular calendar spraying of pesticides or of applications of inorganic fertilizer. They require a level of analytical skill and certain basic training, and the capacity to monitor on-farm ecological processes. However, evidence suggests that, given the appropriate incentives, farmers are willing and capable of adopting such management practices. In recent years IPM that focuses mainly on better scouting for pests, rotations and other cultural practices has become widely adopted in the USA. On many crops IPM is used on more than 15% of the total acreage; for some, such as apple, citrus and tomato, it is now the preferred approach (NRC, 1989).

Such large scale change can bring enormous financial benefit to both farmers and national economies. As a result of rice-IPM programmes in SE Asia, farmers have acquired the principles and approaches, so cutting insecticide use by 50% as well as increasing rice yields. The 50% reduction in pesticide use represents annual savings of US$5-10 million for Thailand and the Philippines, and $50-100 million for Indonesia (Winarto, 1992; Kenmore, 1989; Kenmore et al, 1987).

4.2 Selective Use of Pesticides[1]

Although agricultural pests and pathogens are thought to destroy some 10-40% of the world's gross agricultural production, pesticides are not the perfect answer to controlling pests and pathogens (Conway & Pretty, 1991). They can be dangerous to human health and damage natural resources but, more importantly to the farmer, pesticides are often inefficient at controlling pests. They can cause pest resurgences by killing off the natural enemies of the target pests. They can produce upset pests, by killing off the natural enemies of species which hitherto were not pests. Pests and weeds can also become resistant to pesticides, so encouraging further applications. Now there are some 470 pest species worldwide known to be resistant to at least one product and, in Britain, some critical weeds and diseases, such as blackgrass and barley mildew, are now difficult to control. And lastly, pesticides provide no lasting control, and so, at best, they have to be repeatedly applied.

Most pest species are naturally regulated by a variety of ecological processes, such as by competition for food or by predation and parasitism by natural enemies. Their numbers are more or less stable and the damage caused is relatively insignificant. High input farms, though, are very different from natural ecosystems. Fields are planted with monocultures of uniform varieties, are well watered and provided with nutrients. Not surprisingly, these are ideal conditions for pest and pathogen attacks, and frequently the scale and speed of attack means that farmers can only resort to pesticides. Low input systems, by contrast, make use of the agroecological processes of predation, competition and parasitism to control pests better than pesticides alone.

The first strategy is to use pesticides that do not lead to pollution, and ideally do not interfere with natural enemy control, nor result in the pests or pathogens evolving resistance. Needless to say, this is not easy. Many of the newer pesticide compounds are more selective, less damaging to natural enemies, and less persistent in the environment. One consequence of greater regulation is the development of a number of chemicals that are highly targeted in their effect. These include compounds that act as mimics of juvenile hormones in insects, the particular advantage of which is that they only work on a single pest species, and new herbicides that inhibit photosynthesis. Many of these carry little or no environmental hazard, as far as is currently known (Conway & Pretty, 1991).

Farmers throughout the world have long used a wide range of locally-available compounds to repel, deter or poison pests of their crops and animals. Many of these are both selective in their action, killing pests and not predators, and degrade rapidly so do not contaminate the environment. Some, though, are toxic to people and broad spectrum in their action, and so are not different to many synthetic products (Conway and Pretty, 1991).

The most widely used of natural plant compounds are the antifeedants that render plants unattractive and unpalatable to pests (Saxena, 1987). The most common are derived from neem (*Azardirachta indica*), which occurs over wide areas of Asia and Africa. Almost every part of the tree is bitter, although the seed kernel possesses the maximum deterrent value.

[1] The term pesticide is used here as a generic term that refers to products that control insects and mites (insecticides, acaricides), diseases (fungicides) and weeds (herbicides).

The derivatives are known to repel insects and to cause pronounced behavioural and physiological effects (Saxena, 1987; Stoll, 1987). It is also safe for people. The seed is most commonly formulated in an oil or cake: in parts of India neem cake has been applied to the rice since at least the 1930s. Neem extract controls Colorado Potato Beetle sufficiently well to give up to 50% better yields than unsprayed potatoes (Zehnder & Warthen, 1988).

Equally promising, in terms of selectivity, are pesticides based on bacteria and viruses. The greatest successes so far have been preparations of *Bacillus thuringiensis (B.t.)*. The bacillus produces a crystalline compound, which dissolves when ingested by the larvae of moths and butterflies producing toxic proteins that paralyse the gut and mouthparts. Strains of *B.t.* have been used against moth pests for 25 years, and recently discovered strains have been shown to be active against a range of other pests including nematodes and mites. However, resistance to *B.t.* has been reported in USA, Japan, Philippines, Thailand and Taiwan, particularly where *B.t.* products have been repeatedly applied as a spray or incorporated into crops. The crystal toxins of *B.t.* are produced by a single gene, which has now been inserted by genetic engineering techniques into non-pathogenic bacteria that colonise plants roots, and also directly into crop plants such as tomato and tobacco. According to the OECD, field releases with transgenic tobacco, cotton and tomatoes have taken place in the USA, Israel and Spain. But restrictions on genetically engineered organisms have not yet permitted extensive field trials.

Some strains of bacteria are also effective at controlling crop diseases, such as *Agrobacterium*, which produces an antibiotic that controls crown gall tumours of orchard trees and ornamental plants (NRC, 1989). Antibiotic substances produced by the bacterium *Streptomycete* have been formulated into a biofungicide, and inhibit growth of *Rhizoctonia* in oil seed rape, *Fusarium* on cereals, *Pythium* on sugar beet and *Alternaria* on cauliflowers (FW, 1992b). Other new biopesticides include products based on fungi and toadstools. Although the demand for 'biopesticides' is growing rapidly, the market share remains small in relation to the £416m annual UK pesticide market.

4.3 Reduced Use of Pesticides

The alternative to seeking safer compounds is to rely on more efficient and careful application of existing pesticides. Most damage arises today not so much because of the intrinsic characteristics of the pesticide compounds but because of the way they are used. There is increasing evidence that farmers can reduce their pesticide applications by more precise targeting of pests and weeds without suffering any reduction in profitability. They substitute labour and knowledge for some of the external inputs, as there is more management of farm resources to encourage predators or discourage pests, as well as more labour required for pest monitoring.

Research at the Scottish Agricultural College is showing that if farmers get the timing of applications of fungicide on cereals right, they can cut rates by 50-75% and still maintain yields (SAC, 1992; Wale, 1993). Researchers recommend that farmers regularly examine crops and apply a quarter-rate mix when 75% of plants are showing at least one active mildew spot. And in experiments at ADAS Kirton, sequential sampling for pests on brassicas has reduced the need for pesticides by 85%, whilst maintaining yields (FW, 1993b). But these low dose approaches do place extra management demands on farmers. As Stuart Wale of SAC put it: *"the use of low dose mixtures is not appropriate for all growers. It is primarily intended for those who can inspect crops regularly and make a timely application of fungicide"* (FW, 1993c).

One emerging approach is patch spraying. This needs a combination of appropriate technology, regular field monitoring and modified spray systems that allow spraying where there are known problems. A field map showing the location of weeds is first made up by using a combination of aerial photography, image analysis of maps and field walking. This information is then stored in a tractor-mounted computer which also controls the sprayer. In the field the operator enters the location of the tractor and a distance-speed monitor tracks the position as it moves. On-board computers measure position against the pest or weed maps, and so dispense herbicides or pesticides only where they are needed. The impact on cost reduction can be considerable. John Morrison, who farms in Derbyshire, has cut herbicide bills by 95% in some fields with no impact on cereal yields. He saved £1700 by patch spraying, indicating that: *"we'd have had to spray the whole lot if it hadn't been for the modified spray system"* (FW, 1993d). In effect, he is substituting back labour and knowledge for the former dependence on external measures for pest control.

Patch spraying can be further helped by the utilisation of the global positioning system (GPS). The GPS utilises signals from satellites to fix the precise position of a tractor or combine harvester within a field. The system can produce yield maps for fields by combining data from existing yield monitors on combines with the exact position in the field. Yield variations within a single field can be up to 4 t/ha, and yield map can then be used to match subsequent inputs to location specific requirements. One farm manager in Humberside has cut nitrogen rates by 30%, so reducing the amount of nitrogen leaching out in the field drains by 60% (FW, 1991a). Seed, pesticide and herbicide rates can all be matched to the variations within a field. As another farmer, John Fenton, put it: *"it must make sense to tailor input levels to as small an individual area as possible. Blanket rates over a large area are wasteful"* (FW, 1993e). And because many factors affect crop yield, the technology is best used in combination with soil analysis, regular field walks and monitoring.

4.4 Reintroducing and Enhancing Natural Enemies

In natural conditions many natural enemies of pests may be present, commonly acting together to regulate pest numbers. One problem with pesticide use is that if all the pests are killed, the predators have nothing to feed on and so also die. Ideally the pest population needs to be brought down to a desired level and maintained there, hopefully permanently. This implies that the pest population is not eradicated and so is tolerated to an extent.

The use of natural enemies is usually referred to as biological control. The term sometimes implies any form of non-pesticidal control but it is less confusing if restricted to the use of natural enemies. It is also important to distinguish between what is called *classical biological control* which involves the release of new or exotic natural enemies, and *augmentation* which relies on improving the degree of existing control. Releasing natural enemies is a pollution-free technology; nevertheless there is a risk that the released exotic may itself become an undesirable pest. This is particularly likely when insects are being introduced to control weeds since, in theory, they may turn from weeds to crops. Elaborate screening is undertaken to determine the range of possible hosts which they might attack when eventually released. There has been considerable effort over recent years to develop effective biological control programmes, though few have been successful (Waage & Greathead, 1988; Jutsum, 1988; Herzog and Funderbank, 1986).

Occasionally, the results are spectacular. One success was the control of the prickly pear, *Opuntia*, a cactus that was introduced into Australia as a garden plant from Mexico at the end of the last century. It soon spread to pasture land and by the 1920s some 25 million hectares were infested. Eventually *Cactoblastis cactorum*, the larvae of which tunnel inside and destroy the cactus, was discovered in Argentina and introduced in Australia. Today the cactus only occurs as individual plants or in small patches (Conway, 1971).

Some of the most successful biological control programmes have been against pests of glasshouse crops, such as tomatoes, cucumbers and ornamentals. Pests become inadvertently introduced into glasshouses and rapidly multiply in the controlled and favourable environment, often with devastating effects. However, the high degree of environmental control can also favour the planned release of natural enemies. This was first tried in Britain in the 1970s, not because of a concern over pesticide pollution but in response to the development of pesticide resistance among a number of glasshouse pests (Payne, 1988).

The first target was the two-spotted mite, a serious pest of cucumbers and tomatoes that first appeared in glasshouses in 1949. Releases were made of a South American predatory mite *Phytoseiulus*. It was soon found, however, that broad spectrum sprays killed the predatory mites and the biological control programme had to be rapidly extended. More selective pesticides were used but a second biological control agent, *Encarsia*, a predatory wasp, was then successfully released against the whitefly, one of the most important of the other pests. It is an example that illustrates the importance of establishing effective natural enemy control first and then developing other complementary control strategies. Today, some 60-70% of the UK cucumber crop and 15-20% of tomatoes are subject to biological control.

Some expect significant growth in this market in Britain. The private company Ciba-Bunting supplies biological control agents to farmers, and was recently quoted as indicating that in the future the "*conventional crop protection market is expected to stagnate, while the natural biological products sector expands by 10-15% per year, accounting for 5-10% of the total market within the decade*" (FW, 1993f). Most of this growth is still in glasshouse predators and, as yet, there have been few innovations for field crops.

4.5 Encouraging Natural Enemies with Beetle Banks and Flowering Strips

Natural enemy populations can also be encouraged by increasing the diversity of agroecosystems and their neighbouring environments, and by fostering crops and wild plants that favour natural enemies. Many natural enemies need food sources in the form of pollen or nectar, which can often be provided by wild vegetation in or near the crops. There are usually more natural enemies in fields bordered by diverse hedgerows, and in orchards adjacent to woodlands (Lewis, 1969; Altieri and Schmidt, 1986; Herzog & Funderbank, 1986; El Titi and Landes, 1990). Predators can be encouraged to invade fields. Perennial stinging nettle, for example, is a source of predators of aphids and psyllids and, as predator numbers increase in the spring, so their dispersal to crop fields can be encouraged by cutting the nettles.

Some farmers are maintaining populations of natural predators of cereal pests by encouraging the growth of host plants in beetle banks and conservation headlands. In southern England, several hundred potentially beneficial species of predators and parasites may live in cereal crops. Most of these are killed when the crops are sprayed to control pests. But if the field habitat is manipulated to increase plant diversity, then the need for spraying pesticides can be greatly reduced. When grass strips, usually of the perennial grasses cocksfoot and timothy, are constructed across large fields, then predatory beetles proliferate and can penetrate to field centres, the regions where aphid populations are greatest (Wratten, 1992; UoS/GC, 1992). The cost of establishing a 400 metre bank in a 20 hectare field is about £90, including cultivation, grass seed and loss of crop. In succeeding years the cost of land taken out of production is £30 for the same field. One aphid spray costs £300 across the same field, plus the cost of yield reduction due to aphid infestation. One Hampshire farmer, Michael Malyon, recently created five beetle banks, indicating that *"we never get good yields in our large fields... The cost of putting in the banks in a field is negligible compared with the potential benefits"* (FW, 1993g).

Flowering strips can also be planted to conserve predators. Hoverfly larvae are voracious predators of aphids, and because the adults need pollen and nectar to lay eggs, they thrive on farms rich in wild flowers. Headlands left unsprayed with herbicides support many more predators than those where flowering plants are removed; the weeds attract non-pest herbivorous insects, which encourage hoverflies and other predators of cereal aphids, such as the beetles *Agonum dorsale* and *Bembidion lampros*. The survival rate of partridge and pheasant clicks, which feed on the herbivorous insects, is also greater in these conservation headlands (Game Conservancy, 1993). Some 1800 km of conservation headlands were recorded in England and Wales in 1992, some 90% of which were outside ESAs[2]. Recently, farmers have been experimenting with *Phacelia tanacetifolia*, an blue-flowering ornamental introduced from the USA. This has a long flowering period and again attracts hoverflies. Where it has been planted in strips, the number of eggs laid per aphid is twice as great as in fields with no flowering strips (Wratten, 1992). The paradox is that farmers who are putting in beetle banks and flowering strips may well have been encouraged to remove hedgerows in the recent past.

Another form of beetle bank are alleys of trees planted in cereal fields. Recent research is showing that two metre wide strips of mixtures of hazel, wild cherry, ash, sycamore, and walnut planted 12 m apart provide a good habitat for natural enemies, so permitting pesticide use to be cut (David Corry and Lynton Incoll, pers. comm.). The loss of cereal area to the trees is partially compensated by an increase in yields of some 8% because of better shelter and moisture conservation, and 20-50 years later by the timber harvest.

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[2] Farmers receive £110 per hectare of conservation headlands in the Brecklands Environmentally Sensitive Area (ESA),; and £60 per ha in the Wessex Downs and Sussex Downs ESAs.

4.6 Rotations and Multiple Cropping to Reduce Pests and Diseases

Crop rotations are a central component in the development of less intensive farming, with the maximum use made of crops that contribute to soil fertility and reduce pest damage. The approach is to rotate non-host crops with susceptible crops in sequence. While the non-host is growing, the pest or pathogen populations decline so that they are very low or absent when the susceptible crop is grown again. The non-host crop provides a break, disrupting the relationship between a pest or pathogen and its host. It is a practice that rarely has ecological or economic drawbacks, and many farmers regard rotation as an essential part of prudent management.

It is well established that monocropped modern cereals do not maintain initial yield levels, whether fertilized or not. Although many factors affect the performance of wheat, yield is most strongly influenced by its position in a cropping sequence. First wheats in a rotation sequence yield the most, mainly because of residual nutrients and the reduced pressure from trash-borne diseases (Jordan et al, 1993). First wheats are grown for their milling and breadmaking qualities, and so also may command a price premium. A second wheat (wheat grown after wheat) typically yields 15% less than a first wheat, equivalent to about 1 tonne on an average first wheat yield of 7.8 t/ha. Second wheats also require more fertilizer. Third wheats can yield 10-15% below second (Nix, 1992).

Despite the yield reductions associated with continuous wheat cultivation, the policy environment faced by growers over the last fifty years has worked against diversification and the use of integrated crop rotations. Guaranteed cereal prices have, in some instances, resulted in continuous cereal production in areas that are not particularly suited to producing cereals. Decline in fertility and breakdown in soil structure, of course, have to be compensated for by increased external inputs.

Sowing date also has a pronounced effect on the incidence of pests, diseases and weeds. During the past decade, winter wheat has been increasingly sown in September, as early establishment is considered the basis for high yields. But winter cereals sown in September are at greater risk from a range of pests, diseases and viruses, including BYDV, powdery mildew, rusts, gout fly and frit fly. Transmission of BYDV is by autumn migration of aphids from existing grasses and crops, and early autumn sowing creates a green bridge that allows transmission of the virus. Recent research suggests there is little or no loss of yield if crops are sown at the more conventional time of mid-October (Jordan et al, 1993). This means sowing dates could be selected to minimise pest damage. However, late sowing could be bad for soil erosion, as there is less vegetative cover during the winter months of heavy rainfall.

The retention of spatial and structural diversity through multiple cropping practices is as important as rotations. Generally the more diverse an agroecosystem, the less abundant are herbivore pests though, in some mixtures, herbivores do prevail (Conway and Pretty, 1991). Different crops can be grown row by row, or in alternate strips each consisting of several rows of the same crop, or they may be grown in a more complicated spatial pattern or, indeed, at random. Mixtures of spring barley varieties, for example, provide good control of powdery mildew. Even though pure stands treated with fungicides yield slightly better than untreated mixtures, the untreated mixtures provided better economic returns (Wolfe, 1981; Wolfe and Barratt, 1986).

There are various factors in crop mosaics that help constrain pest and pathogen attack. For instance a host plant may be protected from insect pests by the physical presence of other plants that may provide a camouflage or a physical barrier. The odours of some plants can also disrupt the searching behaviour of pests. Grass borders repel leafhoppers from beans, and the chemical stimuli from shallots and onions prevents carrot fly from finding carrots.

Alternatively one crop in the mosaic may act as a trap or decoy - the so-called 'fly-paper effect'. Similarly crucifiers interplanted with beans, grass, clover or spinach are damaged less by cabbage maggot and cabbage aphid. There is less egg-laying on the crucifiers and the pests are subject to increased predation. Interplanting can also be combined with selective use of pesticides, applying them at the appropriate time but solely to the trap crop. Weeds in a crop also increase diversity. In Brussels sprout fields, the presence of weeds reduces damage by aphids, and pests tend to be attracted to weed-free fields (Herzog and Funderbank, 1986; Altieri and Liebman, 1986).

4.7 Using Resistant Varieties and Breeds

During selection and breeding to produce high yielding crop varieties and livestock breeds, many of the natural defences of plants are lost. This may be deliberate since bitter compounds reduce the palatability of plants to humans as well as wild animals. When breeders attempted, in the 1960s, to produce cotton varieties with low content of the terpenoid, gossypol, so that cotton seeds could be used for human food, the new varieties were found to be highly susceptible to insect attack. But, often the loss is inadvertent. The breeder's primary aim is increased yield and by focusing selection on the genes that govern yield characteristics, the genes that confer protection may not be retained.

However, evolution also works to counter the breeders' selections. New species of pests and pathogens appear and, more important, new strains of existing pests and pathogens that overcome the hard-won resistance. One example is the sorghum greenbug in the USA (NRC, 1989). In 1968, greenbugs caused US$100 million loss to the sorghum crop, and farmers spent $50 million the following year to control the pest. By 1976, however, resistance to the greenbug was found, and new hybrids were cultivated on 1.5 million ha. A new biotype then emerged capable of attacking this hybrid in 1980, but again researchers were successful at breeding a new resistant variety.

For low input farmers, resistant crops and livestock represent an important alternative to pesticides in controlling pests and pathogens. Despite the often 'treadmill' nature of breeding for resistance, it remains the most successful alternative to pesticides in controlling pests and pathogens. It also offers considerable promise for the exploitation of genetic engineering techniques. In theory, resistance genes can be inserted into high performing crop plants without any adverse effects on their other desirable characters. The engineered plants will reproduce normally, passing the anti-insect or anti-disease genes to their offspring. Field testing of genetically altered tomatoes and tobacco has pointed toward some success for these 'pesticidal' plants, but as yet they have not been made available to farmers.

Most of these treadmill problems occur because modern varieties are not planted in mixtures and, if palatable, present pest and diseases with considerable unchecked opportunities for population growth. However, planting a diversity of varieties or genotypes in a field can help to harness the inherent variability in pest and pathogen resistance. One option is to create multilines by mixing seeds from similar lines of a crop variety. The lines are very similar in most of their characteristics, but have different genes for resistance. In theory, when new strains of a disease appear only one or two of the lines will prove susceptible. Build up of the disease is slow, an epidemic is prevented and most of the crop escapes damage.

4.8 Disrupting Pest Reproduction with Pheromones

Some pest populations can be controlled by disrupting their reproduction. Synthetic chemicals that mimic pheromones, the hormones released by females to attract males, will reduce the chances of insects mating, while the release of large numbers of pre-sterilized males will ensure that most matings are sterile. Both of these approaches have been widely employed in the USA and some countries of the Third World. But for them to be effective requires intervention at a very wide scale, involving cooperation among large numbers of farmers. So far they has only been effective on large enterprises or as part of government or cooperative run schemes, such as for control of screwworm and pink bollworm in the southwestern USA (Knipling, 1960; NRC, 1989), and cotton bollworm in Egypt (Campion et al, 1987).

Similar to pheromones are juvenile hormones, which kill or prevent insects from reaching a mature stage for reproduction. As metamorphosis is prevented, the insects are biologically dead, and the population eventually ceases to exist. These compounds offer the possibility of being active only in certain insects, with no biological activity in other organisms. They have not yet been used in field crops.

4.9 Improving the Efficiency of Fertilizers

It is virtually impossible to maintain crop production without adding nutrients. When crops are harvested, nutrients are invariably removed and so have to be replaced. There are a variety of sources: the mobilisation of existing nutrients in the soil and parent rock; the fixing of nitrogen from the atmosphere, or the supply of organic or inorganic fertilizer. The application of fertilizer, ideally, should closely match the precise needs of plants but often farmers, for reasons of cost, will apply fertilizer in fewer and larger doses. Inevitably, fertilizer is applied in excess of need, so some nutrients are lost from the farm as nitrate or phosphate to surface or ground water, or as ammonia or nitrous oxide to the atmosphere. On average, some 30-60% of applied nitrogen is lost in non-irrigated farming, rising to 60-70% from paddy cultivation (Conway & Pretty, 1991). This represents a substantial loss to farmers.

Efficiency of uptake is influenced by the crops themselves, the soil type, the timing and appropriate placement of fertilizers, and the presence of factors that inhibit the conversion of nitrogen to compounds easily lost to the environment. Probably the most effective means of reducing current levels of contamination, at least in the short term, is to modify the way in which inorganic fertilizers are applied. As with pesticides, the timing and amounts of application and the nature of the compound applied are all important.

If reserves in the soil are known, then it is possible to make fertilizer recommendations tailored for the specific requirements of each field and each crop. In the UK fairly precise recommendations are based on cropping practice and, in particular, on the crop previously grown on the land (MAFF/ADAS, 1988). Cereals are assumed fully to deplete reserves, for instance, whereas pasture leaves high reserves for the next crop. The outcome is a set of recommendations for nitrogen fertilizer application rates dependent on both reserves and soil type. For instance, it is recommended that winter wheat likely to yield less than 7 t/ha when grown on sandy soil with low reserves should receive 175 kg N/ha. But if the reserves are high and the soil a clay, then no fertilizer needs to be applied.

Nutrient uptake and absorption can also be improved by using slow-release products or by incorporating, with the fertilizer, compounds that inhibit bacterial conversion of one nitrogen compound to another. For example, ammonium nitrogen may be converted in this way to nitrate which is then available for leaching. One answer is to incorporate compounds, such as dicyandiamide, that will inhibit bacterial action, into ammonium nitrate fertilizer. This technique has been employed for some time in the USA and has proved successful in maintaining the nitrogen as immobile ammonium and, hence, in controlling leaching and gaseous losses.

Low-input farmers are likely to be the greatest beneficiaries of deep placement fertilizers such as urea briquettes, urea marbles or urea supergranules, as a small quantity of fertilizer is now capable of going further. Nutrient uptake and absorption can also be improved by using slow-release products coated with sulphur. Sulphur-coated urea reduces the need for split applications and helps to fulfil sulphur requirements of the crop. Appropriate placement is as critical as the timing and the amount of fertilizer applied. One system that utilizes appropriate placement is the ridge tillage commonly used in the USA, but also used for potatoes in the UK, in which fertilizers are drilled into the ridges to ensure they are placed beside the seed.

4.10 Conserving Existing Nutrients

The way in which the soil is tilled can have a significant influence on how well soil nutrients are retained. In conventional tillage, the topsoil is inverted and mixed by means of a mouldboard plough or disc, or a handtool such as a hoe. This serves to incorporate most of the crop residues or stubble and the nutrients they contain. However, these is a lag period from the time the seed is sown to when there is sufficient vegetative cover to prevent soil erosion by wind or water. An alternative approach is to use no, or greatly reduced, tillage in which the soil surface is disturbed as little as possible. Significant quantities of residue then remain on the soil surface, so helping to reduce run-off, sediment loss and loss of nutrients. The seed is directly drilled through the layer of residues. In no-till farming soil preparation and planting are done in one operation; in reduced till there is limited preparation with disc or chisel plough.

These conservation tillage systems are widely promoted in the USA by the Soil Conservation Service. During the 1980s, the area devoted to conservation tillage grew from 16 million to some 40 million hectares, the latter being equivalent of about 38% of all harvested land in the USA. Leaching losses of both nitrogen and leachable pesticides tend to be lower under directly drilled wheat compared with conventionally ploughed wheat (Conway and Pretty, 1991). Such practices are not common in Britain.

Another approach to conserving soil nutrients is to resort to a wide range of physical structures, such as terraces, of varying scale that can be used to contain soil and nutrients. Most of these are designed to check the surface flow of water, and thus perform the dual role of water harvesting and retention. If successful they can minimize the need for fertilizer application although, of course, in some situations they may simply encourage surface water loss rather than to groundwater. Again, these are not used in Britain.

An alternative to physical structures is to plant crops along contours. As water flows across the surface so it meets with rows of crops growing perpendicular to the flow, which slow it down and improve infiltration. Alternatives to perennial grass strips include the use of woody shrubs and trees, which not only protect the soil, but can provide fodder, fuelwood and timber. It has long been the practice in the countries of the Mediterranean to plant rows of trees such as olives with bands of cereals or vines in between. This practice is now common in many parts of the USA as part of Best Management Plans and the Conservation Reserve Program. Contour planting is not likely to be widespread in the UK, however, because of the nature of slopes (R Evans, pers comm. 1993). Many are too steep for ploughing on the contour with existing machinery. A more viable alternative is mosaics of crops that slow down or prevent surface water flow over long slopes.

Soil, water and nutrient conservation is also furthered by the use of mulches, cover or catch crops. Mulching involves spreading organic or inorganic material on the soil surface to provide a physical cover which helps create a micro-environment in the topsoil that is largely independent of the weather. It protects the soil from erosion, desiccation and excessive heating, thus promoting optimal conditions for the decomposition and mineralization of organic matter. The cheapest and the easiest method is to use crop residues, which may come from previous crops, from nearby perennials, such as in alley cropping, or be brought from wild areas, such as reeds from swamps.

Cover crops consist of vegetation that is deliberately established after or intercropped with a main crop, not with a view to harvest but to serve various conserving functions. Cover crops may take up residual soil nutrients that would otherwise be lost, and nitrogen uptake of 40-90 kg/ha has been recorded when white mustard or *Phacelia* are planted as catch crops (Jordan, pers. comm., 1993; FW, 1991b). This is a particularly valuable practice on the light, erosive and leachable soils used for sugar beet cultivation. Land prior to the sowing of beet is often bare for as much as nine months but, when catch crops are sown in August-September, they provide ground cover throughout the winter.

4.11 Legumes and Green Manures

The impact of legumes grown together with or before a cereal crop can further reduce and sometimes eliminate the need for nitrogen fertilizers. Symbiotic bacteria present in nodules on the roots of the legumes can fix a considerable amount of nitrogen from the atmosphere. In a well-nodulated and managed stand of legumes, fixation can be at least 50-100 kg N/ha/year (NRC, 1989; Conway and Pretty, 1991). The cultivation of cereals and legumes crops together can improve both total yields and stability of production. Bushes and trees with nitrogen-fixing capacity also have beneficial effects on plants growing with or after them. Some of this is a result of the fixed nitrogen, but significant quantities can also be supplied in the leaf litter or from intentional pruning.

Undersowing is a once-common practice used now by only a few farmers. Cereals are sown with a legume and/or grass, and these are already established at harvest. This can help control pests and diseases, provide ground cover, and supply nitrogen. Undersowing cereals and brassica with trefoil and clover increases the number of insect predators, reduces the numbers of pests, and gives better crop yields than monocrops (Potts, 1977; Dempster and Coaker, 1974; El Titi and Landes, 1990). Nutrients are also supplied when vegetation is incorporated in the soil as a green manure. It has long been practised; more than 2000 years ago the Romans grew lupins and ploughed them in before sowing cereals. Quick-growing legumes are popular green manures for low input systems, and have the potential to meet much, if not all, of the nitrogen requirements of succeeding non-legume crops.

This may increase nutrient levels, as well as improving the physical properties of the soil. For example, by replenishing soil organic matter, lost through continuous arable cultivation, the incorporation of green manures or livestock manure can improve the soil's structural resistance to raindrop impact and splash and hence erodibility. Infiltration and the water retaining capacity of the soil is also improved and soil micro fauna and floral activity enhanced. The organic matter may be a legume, such as white or red clover, lupins or a crop of peas and beans. Red clover green manures are effective in arable systems: they have been shown to produce winter wheat yields of 6 t/ha with no other inputs (Millington, 1992). By comparison, yields after ryegrass alone are very poor.

Legumes have long been used in milk production systems. However, the advent of readily available and cheap inorganic fertilizers led to a decline in the reliance on legumes to maintain soil fertility. Mixed grass-clover swards gave way to high nitrogen input grass pastures as producers attempted to maximise yields in response to price incentives (J Bax, pers. comm. 1993). Adding nitrogen reduces the content and production of clover, leading to monocultures of grass. But with the introduction of milk quotas in 1984, and the likelihood of further quota reductions as part of the reforms to the CAP, there has been renewed interest in the use of legumes in diary production as a means of reducing unit costs. Clover rich swards can fix 80-280 kg N/ha/yr. Research by the SAC and MMB has shown that grass-clover swards with no application of inorganic nitrogen can successfully support long term diary cattle grazing and intensive silage making under commercial farm conditions. The financial returns from high nitrogen input systems are no greater, and often substantially lower, than the grass-clover system (Bax and Fisher, 1993; MMB/SAC, 1992; Younie, 1992). One important element of clover-based systems is that herbage production tends to be less variable than those fertilized with inorganic nitrogen (Younie and Wightman, 1992).

4.12 Livestock Manures and Sewage Sludge

Livestock manures have been the traditional key to maintaining agricultural productivity since agriculture began. Like plant manures they replenish nutrients as well as but improve soil structure. They have an integral role in traditional rotational cropping systems such as the Norfolk four-course rotation. The nutrient value of manures largely depends on how they are handled, stored and applied. Losses of nitrogen tend to be highest when liquid systems of storage are used and when the manure is broadcast without incorporation. Livestock manures from cattle, pigs and chickens are important for sustainable agriculture, particularly as they positively affect soil structure and water retention, and benefit soil organisms. Soils under integrated farms, for example, have more earthworms than those under conventional management (El Titi and Landes, 1990; Edwards and Lofty, 1977).

Sewage sludge is another potentially important source of nutrients. Domestic and industrial wastes are collected together and treated in sewage works, from which emerge a liquid that can be discharged to rivers or the sea, and a solid material that settles out of the liquid and is called sludge. In the UK, some 1.2 million tonnes of dry solids are produced annually, about half of which is applied to agricultural land. The nutrient content of sludge is low, typically of the order of 3-4% nitrogen, 1.5-3.5% phosphorus and 0.3% potassium, though some sludges can contain more than 10% nitrogen (HL, 1983; EPA, 1989). The availability of these nutrients is also variable. If the sludge is anaerobically digested, the nitrogen is highly available in the form of ammonium compounds. But in untreated raw sludge, the nitrogen is mostly present in organic complexes and is only released slowly by the action of soil bacteria (RCEP, 1979). Nutrients, though, are not the only contents of sewage sludge: it usually contains a large number of contaminants, in particular heavy metals, organic compounds and pathogenic organisms. These can be hazardous to livestock and crops (Conway and Pretty, 1991).

5. Group and Community Action for Sustainable Agriculture

"We recognise the essential part that farms have played in maintaining both the environment of the countryside and also the rural community itself. The social stability which stems from continuity and the commitment to place through rootedness must be included in any calculation of viability" Rev'd John Clarke, 1993

5.1 The Need for Group Action

Although the evidence for the successful use of resource conserving technologies suggests that integrated farms can be economically and environmentally viable, action by individual farmers may not succeed in the long term. Sustainable agriculture needs the collective action of land managers. This is for two reasons. First, the external costs of resource degradation are often transferred from the conventional farmer to the sustainable farmers. And second, one sustainable farm situated in a landscape of high-input, resource degrading farms may produce environmental goods which are undermined or diminished by the lack of support from neighbouring practices.

A necessary condition for sustainable agriculture is, therefore, the motivation of and communication between large numbers of highly independent farmers. Such coordinated resource management applies to pest and predator management; nutrient management; controlling the contamination of aquifers and surface water courses; maintaining landscape value; conserving soil and water resources; and sustaining access to the countryside. Examples of initiatives that will not succeed in the long-term because of lack of nearby support include the following scenarios:

- one farmer encourages predators through beetle banks and conservation headlands, but on neighbouring farms non-selective pesticides which kill predators are used, so preventing local predator populations from reaching a viable size;

- one farmer uses crop rotations, multilines, sequencing and mosaic patterns to keep pest populations below threshold values, with occasional resort to pesticides, but neighbours' pesticide overuse leads to the development of localised resistance to pesticides;

- one farmer maintains a diverse farm of high landscape value, but neighbouring farms reduce the overall value by removing trees, hedges and ponds;

- one farmer opens up land for access to the public, but neighbours do not provide equivalent access;

- one farmer adopts practices that reduce nitrate leaching to groundwater, but other farmers on land overlying the same aquifer continue to apply large amounts of nitrogen or manures, or use practices which permit or encourage leaching;

- one farmer reduces livestock waste losses to surface water, but farmers upstream continue to pollute and so the water quality continues to be poor;

- one farmer adopts soil and water conservation measures in an erosion-prone catchment to prevent run-off damage, but neighbours continue to use eroding practices.

There are fewer cases where farmers adopt regenerative technologies which cause damage on neighbouring land. One example is the adoption of soil and water conservation measures which capture and channel water along the contours, so slowing water flow and increasing percolation, but which can lead in heavy rainstorm to channelling of water onto unprotected neighbouring land causing gullying and leading to worse erosion. In most cases, however, action by an individual adopting sustainable practices produces benefits for the wider environment and society - either by not polluting or by actively improving resource value.

In general, society does not pay or compensate for these benefits. Although certain policy initiatives, such as those for Environmentally Sensitive Areas (ESAs) and the Countryside Stewardship Scheme, are beginning to tackle these issues, they do so only in an individual and piecemeal fashion (see Table 6.1: pages 49-50).

The success of sustainable agriculture depends, therefore, not just on the motivations, skills and knowledge of individual farmers, but on action taken by groups or communities as a whole. This makes the task more challenging. Simple extension of the message that sustainable agriculture can match conventional agriculture for gross margins as well as producing extra benefits for society as a whole will not suffice. What is also required will be increased attention to community-based action through local institutions.

5.2 Group and Community Action in Britain

There is a long history in British farming of group and community action for the effective management of natural resources. Local organisations are crucial for sustainable resource use and development. They develop and enforce their own rules, incentives and penalties to ensure behaviour conducive to rational and efficient use of resources. They are able to make investments and take risks which individuals find hard to make. They are also a forum for negotiation, arbitration and conflict resolution, which arise from diverse individual and group interests. These local organisations can function in a wide range of ways to support regenerative agriculture (Box 5.1).

It is being increasingly well established in the Third World that when local people and farmers participate in agricultural improvements, the benefits to local and national systems can be substantial. Various studies of agricultural development initiatives have found that when people who are already well organised or are encouraged to form groups and whose knowledge is sought and incorporated during planning and implementation, they are more likely to contribute financially and continue activities after project completion (de los Reyes and Jopillo, 1985; Cernea, 1987, 1991; Kottak, 1991; Montgomery, 1983; USAID, 1987; Finsterbusch and Wicklen, 1989; Bossert, 1990; Winarto, 1992; Pretty et al, 1993). If people feel ownership and are committed, then there will be sustained change.

Box 5.1 Functions of local institutions in support of sustainable agriculture

Local institutions can:

- organise labour resources to help produce more;
- mobilise material resources to help produce more (credit, savings, marketing);
- assist some groups to gain new access to productive resources;
- secure sustainability in natural resource use;
- provide social infrastructure at village level;
- influence policy institutions that affect them;
- improve access of rural populations to information;
- improve flow of information to government & non-government organisations;
- improve social cohesion;
- organise labour for conservation tasks;
- provide a framework for cooperative action;
- help organise people to generate and use their own knowledge and research to advocate their own rights.

Sources: Uphoff, 1992; Cernea, 1987, 1991; Curtis, 1991; Pretty & Chambers, 1993

The manorial system of medieval Britain, a classic example of integrated farming, was sustained for some 700 years by a high degree of cooperation between farmers (Pretty, 1990). Groups established detailed management measures for sustainable use of village resources; they provided support and mutual help through sharing arrangements; and they took communal decisions against individuals who attempted to overconsume or underinvest in common resources. Later, during the agricultural revolution of the 18th century, farmers' groups were central in the transfer of knowledge about the new technologies (Pretty, 1991). At a time when there was no ministry of agriculture, no research stations, and no extension institutions, farmers were extremely effective at organising their own experiments and extending the lessons to others through tours, open days, groups and publications.

Elsewhere wetland drainers had to work closely in marshlands and fens to develop local structures to mediate and coordinate action. Local level governance evolved that was close to local people, and was built on the principles of negotiation and balancing of interests. The drainers needed "*to work constantly at the sharing formulae through which they mastered the various tasks that were required to maintain the common good. Through reciprocal obligations and entitlements they developed and controlled a technology that turned low-productivity land into high*" (Curtis, 1991). Another example is the system of crofting, once common in the highlands of Scotland (Hunter, 1991; Maclean, 1990). Crofting too relied on the coordinated action of whole communities, in which farmers cooperated in on-farm activities as well as wider resource management issues, and its survival to today is a measure of the social cohesion of these communities.

A recent study of 157 local sustainable development initiatives in Scotland has illustrated the importance local people give to group action. It indicated that there were environmental, social and employment benefits in the form of increased conservation of resources, a greater sense of community measured in terms of enthusiasm and commitment, and improved direct rural employment (Bryden & Watson, 1991). But the problems faced by these initiatives suggest they are successful despite, rather than because of, the good intentions of support agencies. In particular:

- there was a mismatch between the needs of community initiatives and the support offered by agencies, mainly because funding agencies have narrow mandates and are set up to serve different situations;
- community initiatives had broader aims compared to the narrower ones of donors;
- the tendency was for donors to want to fund capital works rather than the more cost-effective investment in people and skills - small fragile communities do not have the capacity or need to absorb large financial inputs, but do need support at the early stages;
- the undervaluing of the social benefits of community enterprise - most support agencies miss this, yet local people put this high on their list of benefits;
- there is no regular system for disseminating information about local initiatives or for encouraging exchanges between them.

Few modern agricultural programmes or policies have appreciated the importance of institution forming, building or reinforcing. For farmers of one watershed or catchment to treat and protect their land, they must come together to take a common interest. How they sustain and maintain group identity is rarely an issue for external institutions, yet is critical for sustainable and productive use of resources. This is in marked contrast to the emerging wealth of experience of the critical role that local groups play in Third World agricultural development in countries of Africa, Asia and Latin America (Pretty and Chambers, 1993).

In Britain, the rural cohesion required to achieve significant action for agricultural development appears now to be largely absent. This need not be so. Local action needs a catalyst. In the following examples from France and Australia, it is clear what an important role state agencies can play. One model being tested in Britain is the linking of private and public interests for community action. This offers valuable lessons, even though it has not as yet been used for the promotion or development of sustainable agriculture.

5.3 Community Action to Control Soil Erosion in France

In the village of Erlon in Picardie, regular flooding of housing by up to one metre occurred as a result of run off from nearby fields of winter cereals in the mid-1980s (Chambre d'Agriculture de L'Aisne, 1991). Recent land use changes had meant an increase in winter cereal cultivation and loss of tree copses and hedgerows.

In 1987, a local action group was established comprising elected members of the municipality, farmers, research station agronomists, and members of the Chamber of Agriculture. Following several meetings in mid-1987, they conducted a joint technical study. As the farmers lived in the village, they fully participated. All worked together on the planning, with the aim of producing low cost solutions that used available resources and were integrated into the existing landscape. A range of technologies were adopted, including barrages of straw bales anchored to the ground with stakes at the roadside and field boundaries to slow surface water flows; *diguettes* at field boundaries to store water; and ponds and ditches to encourage infiltration of water.

These technologies are still functioning well. Damage no longer occurs downstream, though ditches need regular maintenance to remove sediments. The essential components of success were the action group; the modest nature of the work using local materials; the cooperation between farmers at the catchment level; and the agreements between civil society and farmers on the ownership of the works.

This is in marked contrast to what happens when soil erosion and flooding is the problem in Britain. On the South Downs, for example, the area under winter cereals has grown from 5% in 1979 to 65% in 1992, so increasing the incidence of run-off and flooding of nearby housing (Boardman and Evans, 1991). In the 1960s and 1970s, the 10km² Steepdown catchment, near Sompting and situated on the chalk downs, was primarily grassland for beef and dairy cattle farming, with about 10-15% of the land under winter wheat. During the 1980s, the winter wheat area increased to 60%, and erosion has become a regular and serious problem. The shift to winter cereals means the ground is almost bare during the wettest part of the year. As 6.3 km of hedgerows have also been removed since 1975, there is little to slow the flow of surface water, and so soil is easily eroded. The steep slopes and compacted soils now mean that very large amounts of run-off are generated from relatively small rainfall events. One farm at the lower end of the catchment received 27,000 m³ of water flowing through the house and farmyard in one 2½ hour period. Intense rainfall events when there is good ground cover do not cause floods.

Loss of soil accompanied by flooding has caused considerable damage, resulting in extensive financial costs to householders, farmers, local authorities and insurance companies. Houses built in the 1930s at the bottom of the catchment experienced no flooding until 1980, since when there have been four major floods. Such incidents have led to the issuing of private nuisance actions by both farmers and a local council against those farmers whose practices have allegedly caused flooding and siltation problems from soil erosion and run-off from fields. These actions are costly and time consuming, and do not necessarily result in the adoption of resource conserving practices.

5.4 Landcare in Australia

In Australia, a grass-roots revolution called Landcare has recently turned farming and land conservation on its head (Campbell, 1992; Woodhill, 1992; Alexander, 1993). The National Landcare programme was initiated in 1989 when the major farmers' union and the conservation lobby came together jointly to approach the Prime Minister, proposing that scientists and public officials share the challenge of sustainable agriculture with the wider Australian community. More than 1400 community and farming landcare groups are working to develop more sustainable systems of land use, supported by the national ten year funding programme of $A340 million.

Landcare comprises groups of farmers working together with government and the wider community to solve rural problems. It is an ethic of environmental responsibility, and embodies an 'education and persuasion' rather than 'legislation and coercion' approach to sustainable development. One State coordinator put it this way: "*Landcare is about getting groups of farmers together to tackle common problems. It is for the government to provide funding assistance and technical advice, but for farmers to make their own decisions*" (Viv McWaters, in Alexander, 1993). Landcare groups include those formed to deal with local environmental problems that affect the whole community, such as weeds, rabbits or tree decline; those concerned with conservation cropping (*SoilCare* groups); those concerned with salinity (*Salt Action* groups); and those that focus on farm profitability and business management (*Farm Advance* and *Farm Management 500*).

Cooperation and empowerment has proved to be possible in the most unlikely of social settings, and the nature of farming is being transformed by a network of rural community groups committed to the development and dissemination of productive and sustainable farming and land use. The Programme has achieved great success, but the factor noticed by commentators, local people and farmers alike is the sense of cohesion brought back into rural communities. New relationships are breaking down mistrust: "*It is the first time in Australian history that I'm aware of that farmers and government are working to the same end. They are usually at each others' throats*" (farmer quoted in Alexander, 1993).

Extension staff have become more than providers of information. They are becoming facilitators of learning. They are being trained to work with groups and to help groups become self-reliant: "*We believe that if farmers in a locality are going really to own a broad program concerned with a full range of conservation and production issues, they are going to need a lot of help in terms of being organised and being able to develop goals, consensus around those goals and to develop action plans*" (*SoilCare* manager, in Alexander, 1993).

Although there are many factors accounting for the success of the Landcare programme, one of the most significant is that both environmental and farming lobbies worked together in partnership to establish the programme, leaving behind entrenched positions that had prevented earlier collaboration.

5.5 Private and Public Partnerships in the Community

There are many, relatively small scale, initiatives in Britain that are seeking to foster effective partnerships between local people and external institutions. Under the auspices of Business in the Community, there have been some recent innovations to encourage a closer partnership between public and private agencies in rural areas. These partnerships aim to bring together representatives for one geographical area of central and local government, farmers and landowners, private business, the voluntary sector, and the community. Such a grouping reviews the overall needs of the community in which it operates, explores the scope for concerted action, and initiates individual projects. In the inner cities, such initiatives have developed an image and a vision for their communities which has raised their self-confidence and self-image, so encouraging inward investment and providing a framework for action.

Planning for Real is one notable example of work coordinated by an external agency, the Neighbourhood Initiatives Foundation, that encourages local action, mobilising people in some of the most deprived inner city areas (Gibson, 1991). Another example is the Parish Maps project coordinated by the group Common Ground, who seek to encourage people to work together in mapping their community. As people represent what they value, this helps to build their confidence in their own local knowledge. This is the starting point for engaging with external decision makers (Common Ground, 1991).

With a view to exploring similar scope for action in rural areas, three partnerships involving the public sector and the private sector (including farmers and landowners) were established under the auspices of Business in the Community in Cumbria, Northumberland and Shropshire. They involve people with a thorough understanding of the problems of people in the rural areas in which they live and work who share a determination to do whatever they can to alleviate them. All three counties are overwhelmingly rural though each has a distinctive character and a different mix of agriculture and industry. Each county suffers from the problems of deprivation and agricultural decline described in this paper.

The building of effective partnerships is a long-term business, and it is too early to judge their impact (DoW, 1992). However, in all three counties, there has been:

- leadership from local authorities at all levels, who have been willing to take a positive attitude, to share information, to encourage partnerships, to back individual projects and to look for imaginative solutions to problems;

- contributions of time, expertise and funding from the private sector, the representatives of which tend to be local people running private businesses who have put in a great deal of voluntary effort;

- implementation of successful projects which have been of direct benefit to local communities, and which are capable of replication elsewhere.

But despite impressive commitment and perseverance of those involved, there still remain problems in persuading large companies and national corporations that rural deprivation and disempowerment are real and need coordinated and integrated action. As illustrated by the earlier examples, sustainable agriculture that regenerates local economies can only come about with such coordinated action by all interested parties.

6. Agricultural and Environmental Policies in Britain

"We have failed to appreciate how connected cultural, social and economic issues are. We appear to have an agricultural policy which completely isolates farming from the community, preferring to see it as an 'industry'... We bemoan the loss of fine regional foods, rural schools, village shops and post offices, bakers, local pubs, country markets and even friendly farmers, without ever realising that the are all connected": Sir Julian Rose, farmer, Oxon, 1993

6.1 Recent Agricultural Policy Reforms

Despite the growing recognition of the social and environmental benefits of farming, the principal policy framework of the European Community still enshrines the notion of increased food production at all costs. The Common Agricultural Policy objectives, as outlined in Article 39 of the Treaty of Rome, are to increase agricultural productivity, secure EC food supplies and ensure a 'fair standard of living' for the community's farmers.

The 1992 agreement to reform the CAP does not challenge these objectives. Nonetheless, the reforms do represent an important shift in policy as they begin to weaken the link between productivity and farm income. They introduce a system of direct payments to farmers and a move away from market subsidies as a means of supporting farm incomes. To qualify for these payments, farmers have to comply with a range of specific controls which are intended to restrain production.

EC-wide limits on crop and livestock production were set and, should farmers exceed these limits, they will be penalised in future years by having to comply with more stringent controls on production. Market prices have been reduced, and financial support and incentives linked to specific farming practices introduced. The incentives would appear, therefore, to be present for farmers to comply with new practices, and so reduce food production. Sustainable technologies and practices represent an element of these compliances.

For example, to compensate for a 15% reduction in the intervention price for beef, the Beef Special Premium (BSP) will be increased from £35/head to two payments of around £88/head by 1995. Payments will be made when animals are 10 months and 23 months of age instead of at slaughter, so encouraging farmers to keep animals for longer. Eligibility for payments will also be dependent on stocking densities and producers are required to register all male cattle. In addition to an annual limit being placed on the tonnage of beef that can go into intervention (to be reduced to 350,000 tonnes by 1997 from 850,000t in 1992) regional ceilings will limit the number of BSP that can be paid. If claims for premiums exceed the regional ceilings, then all producer payments will be reduced pro-rata, so penalising all farmers equally. However, it should be noted that farmers will not be prevented from maintaining higher stocking densities greater that those eligible for premiums, consequently the limits will not necessarily prevent over stocking (Baldock & Beaufoy, 1992a, b).

6.2 The Set-Aside Mechanism

Perhaps the most controversial element of the reforms is that relating to the arable sector. Farmers will have to set aside 15% of their eligible land in order to qualify for area payments, intended to compensate them for a reduction in support prices. Although there is a simplified scheme with exemption from set aside for small producers (those producing less than 92 tonnes of those crops covered by the reforms), a high take up of the scheme in the UK has occurred. With the exception of those producers achieving very high yields most arable farmers will have little choice if they want to maintain incomes in the face of falling prices. Cereal support prices are to be cut by approximately 30% in three years.

Compensation payments are based on the average historic yield for regions, rather than individual farms and will therefore result in producers receiving different levels of compensation depending upon whether they are in a high or low yielding region. The UK has been divided into five regions, with England alone forming one region (Baldock & Beaufoy, 1992a). This is in considerable contrast with the 90 regions in France and 274 in Italy.

The regional yield for England has been calculated at 5.93t/ha which will translate into an area payment of £145.73[3] for each hectare planted to cereals irrespective of actual yield. Consequently a farmer in the south west of England with yields below 5 t/ha will receive the same payment as an East Anglian producer obtaining yields in excess of 10 t/ha. The incentive to use large amounts of inputs to achieve high outputs should therefore be weakened. However, with the area payment representing only 15% of revenue per hectare for a farmer achieving an average wheat yield of 7 t/ha, the incentive is by no means removed. By 1995, when the full 30% reduction in support prices is in effect, and area payments have increased proportionally, the area payment will represent some 30% of revenue, based on current yields and prices. As support prices decrease there will be a corresponding increase in area payments. As for the BSP, regional ceilings have been set on the total amount of arable payments available. If total claims for compensation exceed this ceiling, all payments will be reduced pro rata.

Many people have questioned the effectiveness of set aside as a production control mechanism. Some have suggested that the policy could result in an intensification of production on remaining farm land. The incentive exists for individuals to get their overproduction in first, as they will accrue all the benefits whilst the costs are equally shared amongst all the farmers in a base region. It is a classic open-access common property resource problem, with individuals acting rationally if they continue with high levels of output whilst overusing the common resource (here the total funds allocated for compensation). The current requirement for rotational set aside, intended to prevent farmers from fallowing their least productive land, also limits the potential for wildlife and environmental gains. Combined with continued yield improvements, widely estimated to be of the order of 1-2% per year and the agronomic benefits of the rotational fallow, set aside is unlikely to achieve the desired reduction in output for any length of time.

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[3] Based on a green £ conversion rate of 98p/ECU and a notional compensation rate of 25 ECU/t.

As with earlier attempts to reform the CAP, such as the introduction of milk quotas in 1984 and in 1988, legally binding ceilings on agriculture market support and voluntary set aside, the current reforms fail to address the underlying problems within the agricultural sector. With regard to the impacts on rural employment, the current reforms are likely to reduce employment as farmers try to reduce costs in response to falling prices. It has been estimated that one agricultural worker will lose their job for every 130ha of land set aside. With the UK's set aside of 548,000ha for 1993[4], this could result in an additional 4500 job losses (FW, 1993h).

Set aside has been the logical solution to overproduction under the current policy environment. But set aside is unhelpful for sustainable agriculture because it both encourages intensification on the remaining land and undermines the values of farmers. As one English farmer put it recently *"farmers are frightened of set-aside"* (Chris Jones, pers. comm., 1992). To many, it is also fundamentally wrong to leave land unmanaged.

6.3 Environmental Components of Policy

Although there are green slants to the recent agricultural policy reforms, environmental components have largely been secondary to supply constraint. There are, however, a wide range of major grant and incentive schemes available from government and quasi-government agencies (Table 6.1: pages 49-50). These include the ESA scheme coordinated by MAFF, in which farmers enter ten year voluntary management agreements in return for annual payments. There are currently 16 ESAs (to rise to 22 in 1994), covering some 832,000 hectares. Another scheme, the Countryside Stewardship Scheme, is coordinated by the Countryside Commission, and aims to protect and enhance valued landscapes and habitats, and improve the public enjoyment of the countryside. Again, farmers receive payments for entering ten year management agreements. The Nitrate Sensitive Areas (NSA) scheme is designed to limit nitrate leaching to contaminated aquifers. It too is voluntary, and farmers who enter receive payments for following strict guidelines on practices that limit leaching. Taken together these schemes cover less than 1 million hectares of the land in the UK, less than 6% of the 18.7 million hectares of land classified as agricultural.

However, this wide range of schemes is not necessarily supportive of the development of a sustainable agriculture. The main problem is the lack of coordination. The piecemeal action that focuses on individual aspects of a farm, such as a riverside meadow or chalk grassland, does not encourage integrated farming. As a result, farmers may be encouraged to manage sustainably one particular field, but not the rest of the farm. In this way, the internal linkages and processes essential for sustainable agriculture are not promoted.

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[4] A total of 4.27 million hectares of farmland was set aside in the whole of the EC in 1993. The 0.548 m ha in the UK compares with 1.47 m in France, 0.95 in Germany, 0.74 in Spain, 0.23 in Denmark, 020 in Italy, 0.04 in Portugal, 0.04 in Belgium and Luxembourg, 0.03 in Eire and 0.01 in the Netherlands.

Table 6.1 Selection of current environmental grants and incentives available to British farmers

Grant & Coordinating Agency	*Objective*	*Value*	*Requirements*
Environmentally Sensitive Areas (ESA) *MAFF, WOAD*	To safeguard designated areas of the countryside where landscape, wildlife or historic interest is of national importance.	£10-£350/ha/yr.* Eg Tier 3 South Downs ESA, arable reversion to Chalk Downland: £240/ha/yr. Conditions include no use of fungicides, herbicides and fertilizer or cultivations. Tier 1B Test Valley ESA, Unimproved Permanent Grassland: £105/ha/yr. Conditions include restrictions on stocking rates, applications of organic manures and silage production.	Farmers enter ten year voluntary management agreements in return for annual payments. Each ESA has particular environmental objectives with related management requirements and is structured on the basis of various tiers. Currently 832,000 ha covered by ESAs. UK proposals for implementation of Agri-Environment Package would increase this to 1.17 million ha with projected annual expenditure increasing from £11m in 92/3 to £43m in 1994/95.
Nitrate Sensitive Areas (NSAs) (Pilot scheme) *MAFF*	To limit nitrate leaching. To enable UK to comply with EC Nitrate Directive (91/676/EEC) which specifies maximum nitrate concentration of 50 mg/litre at point of abstraction.	£55-£95/ha/yr for basic scheme depending on area. Up to £380/ha/yr for premium scheme involving conversion of arable land to grassland. Eg winter wheat N input to be 25 kg/ha below economic optimum, 175 kg/ha/yr maximum input of organic fertilizer.	Farmers enter voluntary agreements involving restrictions on nitrogen inputs, organic manures and requirements for cover crops. Total area covered by the scheme is 10,700 ha; plans for 30 more NSAs covering 56,000 ha have been proposed.
Countryside Stewardship (Pilot Scheme) *Countryside Commission*	To protect and enhance valued English landscapes and habitats and improve the public enjoyment of the countryside.	Value is variable: £15-£225/ha/yr. Eg regeneration of suppressed heather on enclosed moorland: £15/ha; restoration and conservation of ancient, irrigated water meadows: £225/ha.	The scheme targets seven English landscapes. Landowners and farmers enter 10 year management agreements in return for annual payments. Scheme covers 30,000 ha.
Farm & Conservation Grant Scheme (F&CGS) *MAFF, WOAD*	To help farmers maintain efficient farming systems, diversify into non-agricultural profit making activities and assist in meeting the cost of combating pollution and conserving the countryside.	Value is variable depending upon project and location. Rates in LFAs 25-50%. Farmers in other areas can receive grants of 15%-40%. Funding is available for restoring traditional farm buildings with traditional materials, planting trees as shelter belts and creating hedges and stone walls.	Grants for diversification must form part of an improvement plan, a programme of investments to improve or maintain the farm income, and are available at 25% on investments up to £40,000. Current expenditure £30 million per year, 67% spent on pollution control.
Farm Woodland Premium Scheme *MAFF, WOAD*	To encourage farmers to plant woodland on land currently in productive agriculture.	Annual payments of between £60-250/ha/yr for 15 years for mainly broadleaved woodlands, and 10 years for mainly coniferous woodlands.	Payments are in addition to establishment grants under the WGS but WGS approval must be obtained to qualify.

Table 6.1 continued

Grant	*Objective*	*Value*	*Requirements*
Woodland Grant Scheme (WGS) *Forestry Commission*	To encourage the continued expansion of private forestry by providing establishment grants for creating new woodland or restocking existing woodland.	£615-£1575 per hectare. Better Land Supplements of £400 or £600/ha are available for planting which takes place on arable or improved grassland.	Establishment grants are provided at different rates according to total areas approved for planting or regeneration. Broadleaves attract higher payments to conifers.
Landscape Conservation Grants *Countryside Commission*	To maintain or improve the landscape and contribute to the public enjoyment of the countryside.	Grants available for 25-50% of total costs.	Grants provided for the management and creation of features in the countryside, eg amenity planting of trees and small woods under 0.25 ha, & conservation of ponds, stone walls and green lanes.
The Hedgerow Incentive Scheme *Countryside Commission*	To restore and manage hedgerows whose conservation value is declining because of lack of appropriate management.	£2 per metre of hedge laid; £1.50/m of hedge coppiced; £1.75/m of hedge planted; plus payments for rabbit netting, tree surgery and pollarding, and restoration of hedgebanks.	The scheme was launched in 1992 and will be closely co-ordinated with the MAFF F&CGS. Incentives will be available for a wide range of restoration and management schemes over a 10 year agreement period.
ACCORD *Rural Development Commission*	Improve rural employment opportunities by providing finance for major private sector commercial developments expected to cost more than £250,000.	Up to 50% of total project costs.	Grants available for factory, office and property development, including improvement or expansion, and will normally take the form of low interest loans.
SSSI & NNR Management Agreements *English Nature*	Provide payments for appropriate management practices aimed at the protection of particular habitats and species.		There are now 3700 sites including 140 National Nature Reserves. Current expenditure is in the region of £8 million per year with agreements covering approximately 45,000 ha.
Project Grants *English Nature*	Powers given to EN under the EPA (1990) to give a grant to anybody doing anything which in their opinion is conducive to nature conservation.	Grants available up to 50% of acceptable costs.	Grants principally aimed at safeguarding land of particular importance to wildlife, helping voluntary organisations protect endangered species and encouraging people to become directly involved in community nature conservation projects.

• Capital grants are also available under the ESA and Countryside Stewardship schemes for various environmental improvement works such as hedge laying, creation of new ponds and provision of stone walls. Grants for 'eligible items' in the ESA scheme vary between 30 and 80% of total costs with a maximum £1500 per annum. Under the CSS there are various rates per metre, for different types of fencing, or specific payments for such items as provision of styles and kissing gates.

In addition to these measures to encourage resource conservers, agricultural policies have also focused on penalising polluters. There have been an increasing number of regulations under various acts, such as the Food and Environment Protection Act (1985), the Environmental Protection Act (1990), the Health and Safety at Work etc., Act (1974), and the Water Act (1989). These include the 1986 Control of Pesticides (COPR) Regulations, the 1986 Reporting of Injuries, Diseases and Dangerous Occurrences (RIDDOR) Regulations, the 1988 Pesticides (Maximum Residues in Foods) Regulations, the 1988 Control of Substances Hazardous to Health (COSHH) Regulations, the 1989 Sludge (Use in Agriculture) Regulations, the 1991 Crop Residues (Restrictions on Burning) (No 2) Regulations, and the 1991 Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations.

These have given considerable powers to various agencies to ensure farmers do not pollute. The National Rivers Authority, for example, has to ensure under the Water Act that farmers follow the Code of Good Agricultural Practice for the protection of water, and this includes provisions for direct charging for work they conduct to prevent or clear up pollution.

6.4 Agricultural and Environmental Policy Integration

Although there are is an increasing number of components and areas of action relating to agricultural policy and environmental management, these are still highly fragmented. As yet there is little sign of integration. Sustainable agriculture can only be achieved by integrated action at farm and community level. For it to succeed, this will require the integration of policies too. The problems are acute for farmers. One hill farmer in Wales, Bernard Llewellyn, describes what he has to do to get support for his breeding ewes, suckler cows and tourist-oriented farm: *"the work I have done ... involved making grant applications to the national park, Ministry of Agriculture, Countryside Council for Wales, Dyfed County Council and the Forestry Commission. This is absurd... We need a single scheme and an end to wasteful duplication"* (FW, 1993i).

Environment Ministers of the OECD countries, meeting in January 1991, identified agriculture as one sector in which improved policy integration offered major returns (OECD, 1993). They noted that both environmental and agricultural goals could be pursued within the context of agricultural reform, with a view to moving toward sustainable agricultural practices. This was reinforced by the OECD Council at Ministerial level, which noted that *"environmental policies should be integrated closely so that agriculture is carried out on an environmentally more sustainable basis"* (OECD, 1991).

A range of policy options are available for the better integration of agricultural and environmental policies in support of sustainable agriculture. These are economic, institutional and advisory, and regulatory (Table 6.2).

Table 6.2 Instruments available for the integration of policy in support of sustainable agriculture (Conway and Pretty, 1991; OECD, 1989, 1993)

Economic Approaches	*Institutional and Advisory Approaches*	*Regulatory Approaches*
■ Input charges and taxes as part of the Polluter Pays Principle; ■ Remove or restructure existing subsidies; ■ Implement subsidies for environmental goods and conservation; ■ Permit cultivation of non-food crops (eg arable coppice energy crops) on set aside; or remove set aside altogether; ■ Transferable pollution permits and quotas.	■ Direct advice to farmers; ■ Education via media to farmers and public; ■ Reform of sectoral agencies and modes of work of professionals; ■ Incentives to encourage research into sustainable agriculture; ■ Better consumer choice and marketing (eg eco-labelling); ■ Local groups for participation and empowerment; ■ More private and public partnerships.	■ Restrictions on potentially polluting practices; ■ Prohibition of undesirable practices; ■ Licensing agreements; ■ Standards for pesticide and fertilizer production and use; ■ Appropriate property rights for sustainable land use.

Setting appropriate prices for agricultural inputs and outputs to reflect better their full environmental and social costs is critical to successful policy integration. Market failure, such as non-payment or under payment for resource degradation, or intervention failure, such as under supply of public goods, are important barriers to assigning real prices to raw materials, goods and services.

The use of taxes and charges on inputs has already been introduced in several OECD countries (Table 6.3). There are also proposals to introduce similar taxes in Belgium, Denmark, the Netherlands and Switzerland. Despite appearances, the principal reason has not been to suppress the use of fertilizers and pesticides, and so encourage alternatives. Rather, it has been to raise revenue to subsidise exports (such as in Finland and Sweden), to support research into alternative agriculture (such as in Iowa and Wisconsin), or to return to farmers resources in the form of income support (such as in Norway). There has been evidence of a decline in consumption of fertilizers, especially potassium, in Austria (OECD, 1992). But several additional factors may be important, including revised advice from the agricultural ministry, growing public concern over high rates of application, and general changes in cropping practices. In Sweden, pesticide consumption was successfully halved between 1981-5 and 1990, again though as a result of a combination of factors.

Some countries have also set targets for the reduction of input use. Sweden, for example, aims to reduce nitrogen consumption by 20% by the year 2000; Netherlands aims to cut

Table 6.3 Current taxes and charges on fertilizers and pesticides in selected countries (OECD, 1989, 1992, 1993; Conway and Pretty, 1991)

Fertilizer Taxes		Pesticide Taxes	
■ Austria	£0.28 / kg N £0.17 / kg P £0.09 / kg K	■ Finland	2.5% on retail price
■ Finland	£0.17 / kg P £0.02 / kg N and K	■ Norway	11% on retail price
■ Norway	15% tax on N, P, K	■ Sweden	20% "price regulation" charge, + £3.77 per hectare for each application of pesticides; + 10% environmental tax.
■ Sweden	£0.05 / kg N £0.10 / kg P + additional 20% levy on retail price		
■ USA:			
Iowa State	£0.00048 / kg N		
Wisconsin	£0.00013 / kg N		

pesticide use by 50% by the year 2000 as part of its "Multi-Year Plan for Crop Protection"; and Denmark hopes for a 50% cut in its pesticide use by 1997.

Institutional and advisory approaches are equally important, and relate to the way individuals and institutions encourage better information flows and greater choice with regard to sustainable agriculture. The devolving of administrative responsibilities and development of new linkages between existing agencies are critical elements to foster better integration. This implies better coordination both between different government departments, and between government and non-government agencies. Sometimes it is necessary to establish new institutional mechanisms, such as the *Bureau of Environmental Sustainability* within the Canadian Federal Department of Agriculture, or the *Biological and Integrated Pest Management* section within the Greek agricultural ministry (OECD, 1993). In Australia, better linkages between sectoral agencies and local non-government groups have been an essential component of the success of the Landcare movement (see Chapter 5.4).

The instruments most commonly used in the past for policy making have been regulatory. Regulations tend to act to discourage polluting practices rather than directly encourage sustainable agriculture. To be effective, though, regulations need to be dynamic and keep pace with the evolving challenges associated with agriculture and the environment. The current fashion is to concentrate much more on economic instruments, perhaps to the detriment of both regulations and institutional/ advisory approaches.

What is needed for sustainable agriculture is a combination of these options. The next chapter sets out an agenda consisting of 18 options for policy reform, drawing on a range of these economic, regulatory and institutional measures.

7. Policy Options for Sustainable Agriculture

7.1 Policy Integration

It is not the purpose of this paper to recommend a particular path for policy. Rather, the intention is to set out a range of options[5]. As has been indicated in Chapter 6, there is a need for more integrated and coordinated action if a sustainable agriculture is to be widely promoted and adopted. We have shown that sustainable agriculture is economically and environmentally viable. Yet there are still many constraints to adoption. What has been achieved so far represents what is possible in spite of the existing constraints. So for the transition to occur to a sustainable agriculture, there is a critical need for government to facilitate with an appropriate range and mix of policy instruments and measures.

This chapter sets out a range of options designed to address existing constraints under the three essential areas of action, namely encouraging resource conserving technologies and practices, fostering local group and community action, and restructuring and reorienting existing institutions. In all three areas there are economic, institutional and advisory, and regulatory approaches that can be marshalled to achieve success[6].

Success is defined as the achievement of a sustainable agriculture that is financially viable for farmers, protects natural resources for future generations, and helps to rebuild social structure in rural areas.

7.2 Encouraging Resource Conserving Technologies and Practices

Although many resource conserving technologies and practices are currently being used, the total number of farmers using them is still small. Many of these technologies involve the substitution of labour and knowledge for previously used external inputs. The major constraints to widespread adoption would appear to be that farmers do not yet know enough about these options. A recent survey of arable farmers found that although 70% supported the move to less intensive and integrated farming, they all said they had insufficient information to make the transition (Jordan, 1993).

Farmers also face very real adjustment costs and so, in the short term, they will see many of these practices as too risky. Transition costs arise for several reasons. Farmers must first invest in learning. As current policies have tended to promote specialised, unadaptive

[5] For further information on a range of debates relating to specific aspects of agriculture and rural development policies see the following recent reports: on the transition from current agriculture to organic (Greenpeace, 1992); on nitrogen quotas (FOE, 1991); on the environmental impacts of the agri-environment package and the reformed CAP (Baldock and Beaufoy, 1992a, b); on sustainable agriculture (NFU, 1993); on implementing non-polluting technologies (MAFF, 1991, 1992); and on poverty and stress in rural areas (DoW, 1992; ACORA, 1990; HL, 1990).

[6] These approaches are not intended to represent a complete picture for agricultural policy. In setting out these options, we are are not addressing issues relating to the continuation in the EC and Britain of various demand management measures (such as advertising and produce grading schemes), various supply management measures (such as restrictions on areas for given crops, the restrictions on certain imports, and the use of export subsidies), and various direct payment measures (such as deficiency payments and direct income supplements).

systems with a lower innovation capacity, so farmers will have to spend time learning about a greater diversity of practices and measures. Lack of information and skills is seen as a major barrier to the adoption of sustainable agriculture. During transition they must experiment more, and so incur costs in acquiring new knowledge and information.

The internal biological processes that make sustainable agriculture work 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 and other soil factors; 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, such as for labour for construction of soil and water conservation measures, for replanting of hedgerows, for pest and predator monitoring; for fencing of paddocks; and for purchase of manure spreading and storage equipment.

As there is a need to track and monitor these ecological interactions, farmers using such agriculture must substitute management and local knowledge for external inputs. Farmers thus tend to incur financial penalties, higher investment and variable costs, during conversion, transition and adjustment away from conventional to sustainable agriculture. In such contexts, it is not uncommon for resource conserving returns to be lower than conventional options for up to five years, after which returns are equal or better. One remarkable set of data from 44 farms in Baden Würtemburg, Germany, has shown that wheat, oats and rye yields steadily increase over a 17 year period following transition to a strictly organic regime (Dabbert, 1990). Until those farmers adopting a more integrated and sustainable system of farming are effectively compensated for internalising many of the agricultural externalities associated with intensive farming and for providing various environmental goods and services, there is unlikely to be a widespread adoption of resource conserving technologies.

The options in this section (numbers 1-9) relate to increasing the generation of research to demonstrate the wide applicability of resource conserving technologies, increasing the dissemination of information to farmers, and reducing the perceived short term risks.

- ***Option 1: More Research into Sustainable Agriculture.*** There is a need for more research by agricultural colleges and university departments. This should constitute both more basic research into resource conserving technologies in a wide variety of biophysical and socio-economic contexts, and more analysis and understanding of what farmers are already doing through case studies and participatory analysis.

  Too little is known about the economic and environmental benefits of resource conserving agriculture because of a lack of incentives, including central and local funds, for research. The options are to impose levies on products to fund research, with farmers involved in research planning; impose taxes and charges on inorganic inputs (pesticides and fertilizers) to fund research; and encourage agricultural researchers to develop networks for regular contact with farmers to explore impacts of policy changes and feed these findings back to policy arena.

  Where possible farmers should be involved closely in research design and implementation, as it is they who know best their local conditions. Institutions most capable of working closely with farmers tend at present to be those funded by farmers, such as the crop research centres, and those with good local linkages, such as agricultural colleges and small research stations. Some institutions are already responding to farmers' needs with, for example, the MMB responding to members' requests to fund research into white clover on a range of demonstration farms (MMB/SAC, 1992). As illustrated by the evidence in Chapter 4, little innovative research is being conducted by agricultural departments in the university sector.

- ***Option 2: Farmer to Farmer Exchanges.*** Farmers are the best trainers of other farmers, and so coordinated exchanges and the establishment of farmer study groups can greatly help in information exchange and dissemination. Linking Environment and Farming (LEAF) already uses demonstration farms to illustrate best practice (see farm profiles for Carbrooke Hall and Applesham Farm, Chapter 3). Farmer to farmer exchanges and training is one element identified in the EC 5th Environment Action programme to promote more environmentally sensitive agriculture.

- ***Option 3: Direct Transitionary Support to Farmers.*** Farmers face real adjustment costs when converting to sustainable agriculture, and so a particularly important element is the transitionary period. The necessary policy option is to offer subsidies for just this transitionary period. Subsidies would therefore have the so-called 'sunset provisions'. Such transitionary subsidies would be supported by codes of good management practice to illustrate how transition costs can be reduced or shortened, together with grants, subsidies or low-interest loans for resource conserving machinery, equipment and so on. The adoption of transitionary payments, or conversion grants, has been used for encouraging farmers to convert entire holdings to organic practices in Germany, Denmark, Sweden, Norway and Switzerland.

- ***Option 4: Direct Subsidies, Grants and Low-Interest Loans for Sustainable Technologies.*** As detailed in Table 6.1, there are many separate conservation and environmental schemes currently available to landowners and farmers. However, the schemes are fragmented and the two core land management schemes, ESA's & the CSS, restricted to designated areas or specific landscapes, account for less than 6% of the UK's agricultural land area. What is required are nationwide initiatives available to all farmers. Policies should be relevant to local conditions and requirements, a welcome feature of the ESA scheme, but not restricted to those farmers who happen to farm within a particular designated area. Such fragmentation is in sharp contrast to the pilot MEKA project in Baden Würtemberg, south west Germany, where the principle is to pay farmers not to damage the environment. The scheme is voluntary and open to all farmers, who are able to choose the aspects of the scheme with which they wish to comply. They then receive payments on a points system (Table 7.1).

Table 7.1 The MEKA grant scheme, Baden Würtemberg, Germany (FW, 1992c)

The MEKA scheme aims to reduce overproduction and promote more integrated and environmentally sensitive farming. Points, worth a cash payment of around £7 each, are awarded on a per hectare basis for specific agricultural practices. For example, using no growth regulator attracts 10 points; sowing a green manure crop in the autumn earns 6 points, applying no herbicides and using mechanical weeding gets 5 points; cutting back livestock to 1.2-1.8 adult units per hectare brings 3 points; and direct drilling on erosive soils earns 6 points. Direct environment protection measures include up to 15 points for reduced stocking on areas designated as of special scientific interest and points can also be earned for keeping rare breeds. The total cost of the scheme in the first year will be £32m and will be split between the Federal government and the regional government. *"By encouraging care of the environment and the traditional landscape with grant aid, the scheme is helping family farming businesses like ours to survive"* says George Mayer, who farms a 60ha mixed farm. More than 43,000 farmers have joined this scheme to date.

- ***Option 5: Area Payments Linked to Resource Conserving Practices.*** Set aside has been the logical solution to overproduction under the current policy environment, but there is a need for some broader thinking. At present, area payments are not closely tied with resource conserving practices. One option would be to tie together whole farm management agreements with area payments, so ensuring integrated and productive farms. This may in the end mean that set aside is no longer needed, as production will fall with the wide adoption of sustainable agriculture.

- ***Option 6: Penalise Polluters with Taxes, Levies or Quotas.*** Current policies tolerate external environmental and public health costs because of lack of markets for public goods, such as landscapes, soil, biodiversity, and groundwater quality. These external costs are not accounted for by farmers. The Polluter Pays Principle seeks to reverse this by ensuring that polluters pay some or all of these external costs. The principal policy options are a combination of economic, advisory and regulatory approaches. These include the imposing of charges, taxes or levies (eg on inorganic fertilizers or pesticides); the adoption of transferable rights or permits systems, such as irrigation entitlements, emissions trading, and transferable permits for nitrogen and soil; the establishment of regulations to enforce compliance, such as groundwater protection zones, nitrogen sensitive areas, well-field protection, riverine protection zones, wetland and erodible land protection; and the establishment of strict codes of practice linked to subsidies.

  The attraction of imposing taxes on inputs, particularly on inorganic nitrogen, is that it should reduce surpluses and decrease environmental impacts, such as ground water contamination, at the same time. But these options are not without severe implementation difficulties. The high financial returns available from external input use make it is likely that taxes would have to be set at relatively high levels if they were to achieve a 'desired' reduction in chemical use. Taxes below a certain economic threshold could simply result in an outflow of income from the agricultural sector, with consequent impacts on rural communities, without resulting in any significant reduction in chemical usage. They would simply provide a convenient means of raising revenue for the government without providing any appreciable environmental benefits.

The imposition of quotas without a corresponding grant or income support payment to compensate farmers for the loss of income could result in a further concentration of holdings as more farmers leave the industry. Similarly, tradeable permits or quotas could lead to a concentration of production associated with high input levels on those farm businesses with the resources to purchase quotas.

- ***Option 7: Information for Consumers.*** There is imperfect information for consumers to select food products according to whether resource conserving or degrading practices have been used. The opportunity exists to couple food markets to the environment. Options include new cosmetic standards and publicity campaigns to demonstrate to consumers that poor appearance does not necessarily mean poor quality; 'eco-labelling' of foods so consumers can exercise greater choice (something different to existing organic symbol schemes), linked to increased publicity to demonstrate the difference between products from regenerative and organic agriculture; and the establishment and publication of Maximum Residue Limits (MRLs) for pesticides in foods.

  To some extent, this is already happening with many of the large supermarkets going for quality assurance production methods. But these still tend to be considerably more expensive than conventional products. An extension would be to adopt labels that demonstrate a difference with organic practices, such as for 'integrated green products'.

- ***Option 8: Appropriate Property Rights for Long-Term Investment.*** Sustainable agriculture incorporates the notion of valuing the future availability of resources. But where there is lack of secure tenure and clear property rights, this discriminates against the long-term investment necessary for sustainable agriculture. If farmers are uncertain how long they will be permitted to farm a piece of land, then they will have few incentives to invest in practices that only pay off in the long term, such as soil and water conservation, agroforestry, planting hedgerows, and building up soil fertility. The options are thus to grant property rights; revive tenancy laws (tenant right) that ensured tenants will receive full economic value of any resource conserving investments they have made during course of their tenancy; and encourage action by landlords to set lease conditions that specify the use of regenerative technologies.

  The last option is becoming more common where the landlord is a public body, such as a District Council. In West Sussex, for example, the Adur DC have specified practices for farmers leasing their land to ensure soil erosion and run-off do not cause off-site damage. This might involve the additional use of landscape maintenance contracts and conservation easements to maintain ecological integrity and improve environmental quality.

- *Option 9: Codes of Good Practice*: Codes of good practice illustrate to farmers what is necessary to practice sustainable agriculture. Recent codes issued by MAFF have taken a resource focus by detailing how to protect water, soil and air. These codes have yet to take a wider approach by focusing, say, on integrated pest management or nutrient conservation, or even on rural development.

7.3 Supporting Local Groups for Community Action

As has been illustrated in Chapter 5, coordinated action is necessary for sustainable agriculture to have any significant impact on local and national economies and environments. Such coordinated action would have the benefit of reversing some of the breakdown of social and economic structure in rural communities. The principal current constraints relate to the lack of contact between farmers and other sectors of society, particularly local people in their community, but also with consumers and the wider environmental movement. As external inputs have substituted for labour, many farmers now work alone on their enterprises. Many are lonely, and many cannot afford the time to attend meetings or courses. Others are independent, and do not feel the need to be closely involved with the wider community.

The options in this section (numbers 10-14) relate to findings ways of increasing the social linkages between farmers and communities.

- *Option 10: Formation of Farmer Groups.* The first step for more coordinated local action is better linkages between farmers. Bodies such as the NFU and TGWU (representing agricultural workers' interests) could be coordinating exchanges and the formation of groups for the dissemination of sustainable agriculture. The NFU is already creating better coordinated community linking programmes, and these could be further built on with school and teacher visits, farm tours and information packs for the public. Members of one existing farmers group, the Cirencester Cereal Study Group, put problem solving, friendship, enjoyment and meeting 'others in the same boat' as the most important benefits of their group (Wibberley, 1991).

- *Option 11: Rural Partnerships.* The success of the Landcare movement in Australia has illustrated how people and agencies with apparently conflicting interests can be brought together in partnerships for action. The Business in the Community scheme and other actions by NGOs, such Planning for Real and Common Ground, represent innovative approaches to better participation. But there is a need for a coordinated national approach to rural development that puts community action and social cohesion as the primary goal. The best example in Britain is the recently published *Rural Framework* for Scotland (Scottish Office, 1992). This emphasises the need for local diversity, community involvement in decisions, local added value for products, provision of services, and good networks and communications to achieve sustainable development.

- *Option 12: Financial Support for Farmers' Training.* Many farmers cannot afford the time to attend meetings and trainings. Many complain that they have lost the linkages they formerly had with local communities. There is a need for a scheme to finance the attendance of meetings and trainings, so that farmers can learn about innovative sustainable agriculture practices, as well as rebuild local linkages.

- ***Option 13: Incentives for On-Farm Employment.*** Sustainable agriculture incorporates the notion of greater labour use as a substitute for external inputs. Some of this will be skilled, such as for pest monitoring or hedge laying. Some will require fewer skills, such as for weeding. But most farmers balk at the notion of increased costs incurred by employing more staff. What is required are incentive schemes to encourage employment of local people, particularly young people, on farms.

- ***Option 14: Assign Responsibilities for Landscape Conservation.*** Most ordinary people value in both aesthetic and recreational terms elements of the British landscape, yet they are rarely involved in decisions and processes that shape it. As land managers and owners, farmers clearly should be making decisions about how best to farm their land. But if responsibility could be assigned to both farmers and communities for landscape conserving activities, where local people are encouraged to become involved in local farming in an indirect way, then again more understanding would be created amongst different interests.

7.4 Reforming External Institutions and Professional Approaches

As has been illustrated throughout this report, sustainable agriculture implies the integrated use of resources at local level so as to achieve both productivity and sustainability goals. Yet, most external agencies, both government and non-government, are organised along sectoral lines, so making it difficult for farmers and professionals to engage in meaningful debate and action. Agricultural research and extension professionals both tend to be too narrowly trained, and tend not to work in a multidisciplinary fashion. The commercialisation of information services (such as of ADAS) has reduced their use by farmers, so reducing the links between farmers and professionals. Policy formulation itself, needing to develop enabling and opportunistic environments, is too top-down, with the result that details of local conditions are lost.

The options for this section (numbers 15-18) relate to the wider coordination of policy processes, better working linkages between professionals and farmers, and changes to training and teaching programmes.

- ***Option 15: Coordinate Supportive Policies.*** The first option is to coordinate policies and institutions more clearly. Policies have long focused on generating external solutions to farmers' needs. This has encouraged dependency on external inputs, even when they are financially more costly, environmentally damaging, and therefore economically inefficient when compared with resource conserving options. New policies must be enabling, creating the conditions for development based more on locally available resources and local skills and knowledge. Policy makers will have to find ways of establishing dialogues and alliances with other actors, and farmers' own analyses could be facilitated and their organised needs articulated. Dialogue and interaction would give rapid feedback, allowing policies to be adapted iteratively. Agricultural policies could then focus on enabling people and professionals to make the most of available social and biological resources. This, then, could lead towards a sustainable agriculture.

The Scottish Office's *Rural Framework* is a good example of a process-based policy, in which government is seeking to establish a framework for action whilst recognising that only people in rural areas know the answers. The principles of subsidiarity and shared responsibility, as identified in the EC 5th Environment Action programme, are important in ensuring that the appropriate agencies and institutions have the opportunity to take action.

- ***Option 16: Information Systems to Link Research, Extension and Farmers.*** Sustainable agriculture farmers need more specialised and interactive information systems. This implies the need for new alliances and linkages, particularly for on-farm collaborative research. The need for the adoption and use of participatory methods for research and extension, proven in many Third World countries, is clear.

  The poor linkages between agencies of different sectors and professionals of different disciplines means that farmers and communities are rarely involved in research and extension activities. The problem lies with a critical lack of multidisciplinary and communication skills in professionals, and an adherence to sectoral rather than systems approaches. This means that professionals tend to miss the complexities perceived by people at the local level. Technical solutions, therefore, do exist for resource conserving practices, but these are poorly translated into practical solutions for farmers. The options are to strengthen linkages between agencies and sectors through joint task orientation (best at field level); training and capacity building in the use of community development and participatory methods that are effective in provoking attitude and behaviour changes; and explicit adoption of farmer to farmer extension methods, including developing local expertise through extension volunteers and farmer analysts, and building local groups.

- ***Option 17: Networks to Monitor Policy Impacts.*** For policy to be truly adaptive to changing needs and conditions, policy making institutions need access to feedback and monitoring mechanisms. This is a role agricultural research could play in collaboration with local farmers' groups.

- ***Option 18: Reform Teaching and Training Establishments.*** Sustainable agriculture implies thinking about teaching and learning in quite different ways to current norms. The central concept of sustainable agriculture is that it enshrines new ways of learning about the world (Pretty and Chambers, 1993). Teaching and learning, though, are not the same thing. Learning does not necessarily result from teaching. Teaching implies the transfer of knowledge from someone who knows to someone who does not know. Teaching is the normal mode in curricula; it underpins the transfer of technology model of research; and it is central to many organisational structures (Ison, 1990). Universities and other agricultural 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).

But teaching itself can impede learning. The preoccupation with teaching has constrained the effectiveness of higher education and limited its abilities to meet society's demands. Professionals who are to work with local complexity, diversity and uncertainty need to engage in sensitive learning about the particular conditions of rapid change. 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. Everyone involved in agriculture, including farmers, trainers, educators, researchers, extensionists, and administrators becomes important, as do their interactions. The focus is then less on what we learn, and more on how we learn. Institutions will need to provide creative learning environments, conditions in which learning can take place through experience, through open and equal interactions, and through personal exploration and experimentation. The pedagogic goals become self-strengthening for people and groups through self-learning and self-teaching. This is a huge agenda for the educational establishment. There is little experience to indicate that it would be capable of making such changes.

8. Conclusions: From Sustainable Agriculture to Rural Revitalisation

Until recently, it was widely assumed that sustainable agricultural practices could only bring lower returns to farmers. They were thought to be 'low-input, low-output' practices. It is becoming increasingly clear, however, that integrated farms can match or better the gross margins of conventional farming, even though there is usually a yield per hectare reduction of some 5-10% for crops and 10-20% for livestock.

Detailed tables of evidence have been presented to illustrate the yields and gross margins that have been achieved by a range of crop and livestock oriented initiatives. Profiles of integrated farms have further illustrated the financial viability of sustainable agriculture.

A fundamental challenge for sustainable agriculture farmers is that they cannot go it alone. Resource management that is both productive and sustainable requires all the users to work together for their common good. Such group action is a prerequisite for long-term success. It also becomes the mechanism for forging links between farmers and the wider rural community. Better information flows between all actors are component for an adaptive sustainable agriculture.

Sustainable agriculture creates new challenges for policy. It also articulates with increasingly important debates about sustainable development. These are being shaped by the agreements signed at the UN Conference on Environment and Development, and published in *Agenda 21*; in the EC 5th Environment Action programme *Towards Sustainability*; and the Department of the Environment's consultation paper published in July 1993 *UK Strategy for Sustainable Development*.

At present, however, policy gives support in only a very fragmented fashion. What is required is coordinated action to promote alternative practices that chart a middle ground between high- and no-external input agriculture to encourage adaptive and dynamic agricultural systems that are appropriate to local conditions. An 18 point agenda has been presented that should encourage the adoption of resource conserving practices, support collective action at local level, and reform external agencies. This should help to regenerate rural economies and environments.

Sustainable agriculture benefits farmers, rural communities, consumers and the environment. An extraordinary opportunity would be missed if more were not done to encourage its wider adoption.

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RRA Notes

The principal aim of this series is to share current experiences and methods among practitioners of Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA) throughout the world. The terms PRA and RRA encompass a wide range of approaches with strong conceptual and methodological similarities. These include Participatory Learning Methods (PALM), Agroecosystem Analysis (AEA), Farming Systems Research, Rapid Assessment Procedures (RAP), Participatory Action Research (PAR), Rapid Rural Systems Analysis (RRSA), Méthode Accélérée de Recherche Participative (MARP) and many others.

The series is informal. This is intentional, so as to avoid the commonly encountered delays between practice and the sharing of knowledge through publication. Current issues are distributed free of charge to some 2000 individuals and institutions in 65 countries.

Gatekeeper Series

The aim of this Series is to highlight key topics in the field of sustainable agriculture. The Series is aimed at policy makers, researchers, planners and extension workers in government and non-government organisations worldwide. Each paper reviews a selected issue of contemporary importance and draws preliminary conclusions of relevance to development activities. References are provided to important sources and background material. The Swedish International Development Authority and the Ford Foundation fund the Series.

Forty one papers in the series have been published to mid-1993.

Research Series Charge per issue £5.

Gatekeeper papers (price £2.50 each) are available individually and may be sent out on a regular basis to subscribers. They are distributed free to requests from Third World institutions and individuals.

Current issues of *RRA Notes* are sent out free of charge. Charges for backcopies are on a sliding scale.

For a catalogue and further information on these and other reports and publications, contact:

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The Sustainable Agriculture Programme

The Sustainable Agriculture Programme of IIED promotes and supports the development of socially and environmentally aware agriculture through research, training, advocacy, networking and information dissemination.

The Programme emphasises close collaboration and consultation with a wide range of institutions throughout the world. Collaborative research projects are aimed at identifying the constraints and potentials of the livelihood strategies of rural people who are affected by ecological, economic and social change. These initiatives focus on indigenous knowledge and resource management; participatory methods and processes; and agroecology and resource conserving agriculture.

The refinement and application of Participatory Rural Appraisal methods is an area of special emphasis. The Programme is widely involved in the training of individuals from government and non-government organisations, and in the development of multi-media training materials and teaching aids.

The Programme supports the exchange of field experiences and research through a range of formal and informal publications, including *RRA Notes*, aimed at practitioners of Rapid and Participatory Rural Appraisal, the *Gatekeeper Series* of briefing papers aimed at policy makers, the *Research Series* of reports on the findings of collaborative research reports. It receives funding from the Swedish International Development Authority, the Ford Foundation, and other diverse sources.

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