Chapter 5. Further Empirical Findings and Emergent Issues

Impacts on Rural Livelihoods

5.1 Sustainable livelihoods have been defined in the following way:

> *"a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base"* (Carney, 1998).

5.2 Livelihoods rely for their success on the value of services flowing from the total stock of natural, social, human, physical and financial capital (Coleman, 1990; Putnam, 1993, 1995; Costanza et al, 1997; Daily, 1997; Butler-Flora, 1998; Carney, 1998; Pretty, 1998; Scoones, 1998; Pretty and Ward, 2001). A sustainable livelihood, therefore, means better access to renewable and non-renewable assets and better capacity to derive value from them (see Chapter 1). As the data has shown, most sustainable agriculture projects and initiatives have focused on building natural, social and human capital, as well as seeking ways to improve food production.

5.3 The empirical evidence suggests that the nine types of sustainable agriculture improvements have a variety of positive effects on people's livelihoods. A transition to sustainable agriculture in irrigated systems has only to date delivered a relatively small increase in per hectare grain output. However, whole agricultural systems have become considerably more productive, as they are producing more protein (fish, shrimps, crabs), and more vegetables (on rice bunds and in kitchen gardens). They are also considerably more efficient in their use of water, as well as less polluting. As a result, rural people's livelihoods have improved in a number of ways: such as better food security, more self-reliance, more opportunity for children to attend school.

5.4 By contrast, there are much greater cereal productivity increases in rainfed systems (typically 50-100%, sometimes up to 200% increases), though per hectare yields are starting from a much lower base. In addition, farmers are increasing total farm production by bringing formerly unproductive lands into cultivation, as well as harvesting enough water for an extra irrigated crop during formerly unproductive seasons.

5.5 However, food outcomes are not the only measures of success. Indeed, they might be considered by some people as no more important than some of the improvements to natural, social and human capital. But no simple currency exists to allow the aggregation of all these positive externalities of sustainable agriculture.

5.6 A selection of the impacts reported in the SAFE-World projects and initiatives

include:

i) improvements to natural capital, including increased water retention in soils; improvements in water table (with more drinking water in the dry season); reduced soil erosion combined with improved organic matter in soils, leading to better carbon sequestration; and increased agro-biodiversity

ii) improvements to social capital, including more and stronger social organisations at local level; new rules and norms for managing collective natural resources; and better connectedness to external policy institutions

iii) improvements to human capital, including more local capacity to experiment and solve own problems; reduced incidence of malaria in rice-fish zones; increased self-esteem in formerly marginalised groups; increased status of women; better child health and nutrition, especially from more food in dry seasons; and reversed migration and more local employment.

Labour Markets and Migration Patterns

5.7 At some locations, sustainable agriculture has had a significant impact on labour markets (McDowell and de Haan, 1997; Gordon, 1998). Some practices result in increased on-farm demand for labour (eg water harvesting in Niger), whilst others actually reduce labour demand (eg zero-tillage in Brazil). Some result in the opening up of whole new seasons for agricultural production, particularly in dryland contexts, through improved harvesting of rainfall, leading to much greater demand for labour.

5.8 Migration reversals can occur when wage labour opportunities increase as part of the project (eg watershed improvements), when more productive agriculture leads to higher wages and employment, when there are higher returns to agriculture, and when there are overall improvements in village conditions, such as infrastructure and services.

5.9 There are several documented cases where sustainable agriculture has helped to reverse seasonal or even long-term migration:

- In the Guinope and Cantarranas regions of Honduras, families have returned from the capital city to take up labour opportunities brought by rural economic growth centred on improved agricultural productivity (cf Bunch and Lopez, 1996);
- In India, seasonal migration from a number of rainfed projects (eg in Maharashtra, Gujarat and Tamil Nadu) has declined as sufficient water is now available to crop the rabi season, with women in particular benefiting from being able to remain at home all year[9] (Devavaram et al, 1999);

[9] Kerr et al's study (1998) of watershed programmes in India found a small fall in households migrating from each village: from 19% in 1987 to 15% in 1997. But in control villages (where no sustainable agriculture project), there was a rise from 10% to 13%. The trend for all rural villages in dryland India is increasing out-migration over time. In project villages, 29% of villages had less migration over 10 year period, indicating that there were fewer households migrating, and fewer villages with migrating households.

- In Niger, young men have been able to form labour-societies to meet the demand for water-harvesting construction, rather than migrate to the coast for work.

Dietary and Reproductive Health

5.10 Sustainable agriculture has the potential directly and indirectly to influence the health of rural people. In the first instance, improved food supply throughout the year has a fundamental impact on health, which in turn allows adults to be more productive, and children to attend school and still be able to concentrate on learning. In Kenya, for example, the simple technology of double-dug beds has improved domestic food supply for several tens of thousands of households by producing a year-round supply of vegetables. It is children who have been noted as major beneficiaries.

5.11 In some cases, a more sustainable agriculture can also help to remove threats to health in the environment - such as consumption of mosquito larva by fish in rice fields - with measurable reductions in malaria incidence noted in China. In Jiangsu Province, there has been rapid growth of rice aquaculture: from about 5000 ha in 1994 to 117,000 ha of rice-fish, rice-crab and rice-shrimp systems. Rice yields have increased by 10-15%, but the greatest dividend is in protein: each mu (one fifteenth of a hectare) can produce 50 kg of fish. Additional benefits come from reduced insecticide use, and measured reductions in malaria incidence owing to fish predation of mosquito larvae (Kangmin, 1998).

5.12 Sustainable agriculture can also have an indirect effect on reproductive health. Where women are organised into groups, such as for microfinance delivery (credit and savings), livestock raising or watershed development, such social capital creation offers opportunities or `entry points' for other sectors to interact closely with women.

5.13 In Ecuador, for example, the World Neighbors programme working with remote rural communities on sustainable agriculture and natural resource management has been able to make a substantial impact on family planning (Caudill, 1998; WN, 1998). WN actively compared two types of programme in Guaranda canton, Bolivar Province, by working in six communities that only received health input, and another six that received an integrated programme involving soil and water conservation, green manures, vegetable gardening, and farmer-experimentation with barley, wheat, maize and potato varieties, combined with group formation. The health interventions yielded few results. But the integrated approach brought pronounced changes in attitudes and values. Contraceptive use in these communities was double that in the `health only' villages. The family planning clinic, on the verge of closure in 1992, provided 18,000 consultations in 1998.

5.14 In Nepal, World Neighbors also found that reproductive health and family planning were not effective entry points. Instead, women's reproductive health,

status, work and fertility could be better addressed by forming and working with women's savings and credit groups that could participate in planning a wide range of development activities. Confident groups with better literacy, income and food security were able to challenge traditional roles and norms, leading to capacity to deal directly with reproductive health.

Large Farms, Small Farms and Landless Families

5.15 In certain circumstances, sustainable agriculture practices appear to be currently more accessible to larger farmers - particularly the zero-tillage systems in Argentina, Brazil and Paraguay. However, evidence from Paraguay and Brazil also suggests that larger numbers of small farmers are now adopting and adapting elements of these practices. It is important to note that adoption of sustainable agriculture by large farmers may still result in significant regional change: *"zero-tillage has been a major factor in changing the top-down nature of agricultural services to farmers towards a participatory, on-farm approach"* (Landers, 1999). It is estimated that there are 16 million peasant farmers in Latin America who remain untouched by sustainable agriculture or zero-tillage systems[10].

5.16 But in other contexts, sustainable agriculture has first been adopted by small farmers, and is only now spreading to larger ones once they have seen the success. In Bangladesh, the rice-fish and rice-IPM technologies were adopted by very small farmers first, with larger farmers attracted only when success had been proven.

5.17 Can sustainable agriculture result in improvements in livelihoods for landless families and the core poor? There are three possibilities: improvements to labour markets, improved access to land through land reform, or changed social norms that encourage greater equity and sharing. The first of these seems more likely than the others - though as noted above, some sustainable agriculture applications are favoured by farm families precisely because they reduce labour requirements.

5.18 There is some evidence that social capital formation can result in new equitable arrangements within communities. Landless families, for example, have been given new opportunities to join farmers' groups in western and central Kenya. Such changes cannot be directly attributed to sustainable agriculture - more it is changes in values and norms arising from new configurations of local social capital.

5.19 The greater benefits, though, would come through land reform. MST (Movimento dos Trabalhadores Rurais Sem Terra, or the Landless Workers Movement) was founded in 1985 to access `idle' land owned by absent landlords. It occupied 151,000 ha of such land between 1990-1996 (Langevin and Rosset, 1997). The MST organises occupations, assists in marketing through cooperatives, and helps to create small businesses (eg clothing factories, tea processing plants, dairy

[10] In Brazil, for example,: 1.6% of all farms are over 1000 ha, and these comprise 53% of all agricultural land. Some 30% of farmers own less than 10 ha each, comprising only 1.5% of land (Langevin and Rosset, 1997).

operations). At first, these movements were opposed by local municipalities, but attitudes are changing. The mostly conservative mayors of rural towns strongly opposed MST – until they saw the effect on local economy first hand. Agricultural productivity has been so improved that local economies have in turn received substantial boosts.

5.20 Peter Rosset (pers comm, 2000) states: *"in recent times, their attitude has changed. Most of their towns are depressed economically, and occupations can give local economies a much needed boost. Typical occupations consist of 1000-3000 families, who turn idle land into productive farms. They sell their produce in the marketplaces of the local towns and buy their supplies from local markets. Not surprisingly, those towns with nearby MST settlements are now better off than other towns, and many majors are now actively petitioning MST to carry out occupations near to their towns."*

Social Learning Processes to Understand and Manipulate Megabytes in Fields

5.21 Social learning is a vital part of the process of adjustment in sustainable agriculture projects. The conventional model of understanding technology adoption as a simple matter of diffusion, as if by osmosis, no longer holds. But the alternative is neither simple nor mechanistic. It involves building the capacity of farmers and their communities to learn about the complex ecological and physical complexity in their fields and farms, and then to act in different ways. The process of learning, if it is socially-embedded and jointly engaged upon, provokes changes in behaviour (Argyris and Schön, 1978; Bunch, 1983; Habermas, 1987; Kenmore, 1999; Pretty and Ward, 2001) and can bring forth a new world (Maturana and Varela, 1982).

5.22 The metaphor used here for this new sustainability science is to conceive of fields as being full of megabytes of information – yet we collectively lack the operating system to understand and transform this information (Scott, 1998; Pretty and Buck, 2000). This is information about pest-predator relationships, about moisture and plants, about soil health, and about the chemical and physical relationships between plants and animals on farm. These are subject to manipulation – and farmers who understand some of this information, and who are confident about experimentation, have the components of an advanced operating system. Most of the time, though, this information remains unavailable.

5.23 However, the past decade has seen an increasing understanding of how to develop these operating systems through the transformation of both social and human capital. This is social learning – a process that fosters innovation and adaptation of technologies embedded in individual and social transformation. In the context of developing countries, most of this social learning is not embedded in hard information technology (such as computers or the internet). Rather, it is associated with farmer participation, rapid exchange and transfer of information when trust is good, better understanding of key agroecological relationships in fields, and farmers experimenting in groups. And large numbers of groups work in the same way as parallel processors – the most advanced forms of computation.

5.24 The empirical evidence tells us two important things. Social learning leads to greater innovation together with increased likelihood that social processes producing these technologies are likely to persist.

5.25 Farmer field schools (FFS) have been one of the most significant models for social learning to emerge in the past decade and a half. Farmer-field schools are `schools without walls', in which a group of up to 25 farmers meets weekly during the rice season to engage in experiential learning for IPM (Eveleens et al, 1996; van de Fliert, 1997; Kenmore, 1999). The FFS revolution began in South East Asia, where research on rice systems demonstrated that pesticide use was correlated with pest outbreaks rice (Kenmore et al, 1984). The loss of natural enemies, and the free services they provided for pest control, was a cost that exceeded the benefits of pesticide use.

5.26 The programme of FFS is supported by FAO and other bilateral development assistance agencies and has since spread to many countries in Asia and Africa. At the last estimate, some 1.8 million farmers are thought to have made a transition to more sustainable rice farming as a result. FFS have given farmers the confidence to work together on more sustainable and low-lost technologies for rice cultivation (Pretty and Ward, 2001).

5.27 Recent evidence from farmer field schools in Kenya shows that innovation rates are much greater for FFS farmers than non-FFS. FFS farmers typically produce 3-4 innovations per year, whereas the non-FFS farmers averaged 0.5-1.0 (Martin Kimani, pers comm). Farmers had more options, more confidence to try new things, more capacity to evaluate findings, and more able to share findings with fellow farmers.

5.28 Elsewhere, social capital and experimental capacity of farmers has been developed by CIAT in Latin America in the form of CIALs (Braun, 2000). Some 250 groups have been established in six countries, and these develop their own individual pathways according to the motivations and needs of farmers. These groups decide upon research topics, conduct experiments and draw upon technical help from field technicians and agricultural scientists. Feedback is given to communities as a whole, and regional groupings of CIALs hold annual meetings to share their findings. Members of CIALs talk about being *"awakened about their continuous learning process, and losing their fear of speaking out in public"*(Ann Braun, pers. comm.).

5.29 There have been a wide range of benefits - more experiments by farmers, easier and quicker adoption of new ideas, plus improved food security. And not only do farmers benefit from their experimental findings, they also acquire increased status in the community at large. Maize yields have increased from 800 to 1400 kg/ha, with the result that during August-September, for example, only 30% of households in CIALs still suffer food shortages; whereas 50-65% of households who are not members of CIALs do suffer shortages.

5.30 It appears too that the process of learning is more likely to persist. Mangan and

Mangan (1998) compared farmers in Sichuan, China who had been trained either in FFSs or by the economic threshold (ET) method (spray when a certain number of insects present, or follow calendar spraying). There was good evidence to show that FFS farmers continued to learn in the years after training (continuous learning – vital for sustainability), whereas ET farmers showed no changes in knowledge. Incomes increased for FFS farmers by 23%, mainly because of large reductions in insecticide use, but also because of slightly increased yields compared with ET farmers[11].

5.31 One of the best examples of persistence of learning, and its effect on innovation, comes from studies of sustainable agriculture in Central America. Staff of COSECHA (Associaciòn de Consejeros una Agricultura Sostenible, Ecològica y Humana) returned to the three sustainable agriculture programme areas, and used participatory methods with local communities to evaluate subsequent changes (Bunch and Lòpez, 1996; Bunch, 2000). The first major finding was that crop yields and adoption of conserving technologies had continued to grow up to 15 years since project termination.

5.32 Surprisingly, though, many of the technologies known to be `successful' during the project had been superseded by new practices. Altogether, some 80-90 successful innovations were documented in these 12 villages. The researchers concluded that the half-life of a successful technology in these project areas is about six years. Quite clearly, technologies alone are not sustainable. As Bunch and Lòpez (1996) have put it *"what needs to be made sustainable is the social process of innovation itself"*.

5.33 The value of social learning has recently been reinforced in Central America (Eric Holt-Gimenez, pers comm, 2000). Following the 1998 Hurricane Mitch, 40 NGOs, 100 farmer-technician teams, 360 communities and 24 departments of the three countries of Guatemala, Honduras and Nicaragua were involved in a paired comparison of 1743 sustainable agriculture and conventional farms. Each team of one researcher and two farmers investigated ten examples of the best sustainable agriculture farms and ten neighbouring farms. The owners of both farms accompanied the team, and signed off on the field sheet indicating that the findings were free of bias.

5.34 The research found that the sustainable agriculture farms had greater crop diversity; 20-40% more topsoil and soil moisture; 80% less erosion; retained 1500-1900 litres/ha more water; and experienced lower economic losses during Mitch. A total of 15 workshops were held in the countryside to feed back findings to farmers. But one of the most interesting impacts came from the discovery process: 90% of the conventional farmers participating in the research indicated their desire to adopt their neighbour's sustainable practices.

Improvements to Soil Health

[11] The biases of current research have been shown by Whitten et al (1996), who reviewed 1356 articles on rice pest management published over 30 years, and found only 7 entries dealing with the third tropic level (beneficial insect/spider predators and parasites).

5.35 The most important part of any agricultural system is the soil. It is the fundamental capital asset. When it is in poor health, it cannot sustain a productive agriculture. Many agricultural systems are under threat because soils have been damaged, eroded or simply ignored during the process of agricultural intensification (Cleaver and Schreiber, 1995; RCEP, 1996; World Bank/FAO, 1996; Hinchcliffe et al, 1999; Petersen et al, 2000; FiBL, 2000).

5.36 The situation is now very serious in many contexts. In Africa, there is a negative balance of nutrients amounting to more than 30 kg NPK/ha/year in almost all countries. Some 23 countries are losing more than 60 kg NPK/ha annual deficits (Smaling et al, 1997; Henao and Baanante, 1999).

5.37 Most sustainable agriculture projects and initiatives seek both to reduce soil erosion and to make improvements to soil physical structure, organic matter content, water holding capacity and nutrient balances. This can be achieved through the adoption of a wide variety of physical and biological soil conservation measures, use of legumes and green manures and/or cover crops, incorporation of phosphate-fixing plants into rotations, use of composts and animal manures, adoption of zero-tillage, and use of inorganic fertilizers (Reicosky, 1997; Sanchez et al, 1997; Sorrenson et al, 1998; De Freitas, 1999; Bunch, 2000).

5.38 The diversification of agroecosystems to incorporate nitrogen-fixing legumes and/or blue-green algae substantially affects productivity. Leguminous crops or trees in dryland systems, and *Anabaena* associated with *Azolla* in wetland rice, introduce nitrogen to crops as well as improve the physical properties of soils. The velvetbean (*Mucuna pruriens*), for example, is now grown by tens of thousands of farmers in central America, Brazil and Benin. It grows rapidly, fixes 150-200 kg N/ha/year, suppresses weeds, and produces 35 tonnes of biomass per hectare per year. Addition of this biomass to soils substantially improves soil organic matter content.

5.39 The second sustainable agriculture technology to spread at extraordinary speed is zero- or minimal tillage. In Brazil, there were 1 million hectares under *plantio direto* (zero-tillage) in 1991; by 1999, this had grown to about 11 million hectares in three southern states of Santa Canterina, Rio Grande do Sol and Paraná. In Argentina, there were 9.2 million hectares under ZT in 1999 - up from less than 100,000 ha in 1990 (Peiretti, 2000), and in Paraguay, there were 785,000 hectares of ZT in 1998 (Rolf Derpsch, pers. comm.; Sorrenson et al, 1998)[12].

5.40 ZT has resulted in better input use, water retention, management by farmers, diverse rotations, break crops for weed control (eg ray and black oats between maize/soyabeans) and use of green manures and cover crops. ZT also cuts erosion and water run-off, so reducing water pollution. In many systems, farmers are using herbicides during fallow periods to suppress weeds, but when water is

[12] In the USA, no-till tends still to be simplified modern agriculture systems – so saving on soil erosion, but no use of agroecological principles for nutrient, weed and pest management.

available, they prefer to use break crops during winter for weed control.[13].

5.41 The result is greatly improved cereal productivity. In Santa Caterina, yields have grown steadily over ten years, rising from 3 to 5 tonnes maize/ha and from 2.8 to 4.7 tonnes soyabeans/ha. In Argentina, average cereal productivity was 2 t/ha in 1990; since then, they have increased on conventional farms to 2.2 t/ha, a rate surpassed by those farms with zero-tillage, where yields have grown to 3.5-4.0 t/ha (Peiretti, 2000).

5.42 Farmers are now adapting technologies – organic matter levels have improved so much that they are getting rid of terraces at some locations, insisting that there are no erosion problems. Other benefits of ZT include reduced erosion, and reduced silting of reservoirs; reduction in cost of water treatment; increased water retention in soils; increased winter feed for wild biodiversity. Landers (1999) suggests that ZT represents *"a total change in the values of how to plant crops and manage soils"*.

5.43 This adoption of sustainable agriculture points to a large public good being created when soil health is improved with increased organic matter. OM contains carbon, and it is now recognised that soils can act as carbon sinks or sites for carbon sequestration (Smith et al, 1998; Reicosky, 1998; FAO, 2000). Soils in temperate regions can accumulate at least 100 kg C/ha/year, and in the tropics 200-300 kg C/ha/year. Agroecosystems using green manures and/or zero-tillage can accumulate more – up to 1000 kg/ha/year. Such increases can accumulate over about 50 years before reaching equilibrium. In addition, some forms of sustainable agriculture result in reduced use of fossil fuels (ZT systems can half the consumption of fuel), resulting in a further carbon dividend.

5.44 It is clearly very difficult accurately to say exactly how much carbon is being accumulated in the 29 million hectares of sustainable agriculture in the 208 projects assessed for this research. Without exception, however, they are all making contributions to soil health and carbon content. Assuming a medium rate of accumulation (0.7% or 0.38 tonne/ha/year), and an average of only five years so far under sustainable practices, this suggests an accumulation in these projects of some 55.1 million tonnes (55.1 Tg) of carbon (Pretty and Ball, in prep).

5.45 Such sequestered carbon could soon be a new source of income for sustainable agriculture farmers in the form of carbon emission reduction credits (CERCs). A consortium of seven Canadian energy companies (GEMCo – Greenhouse Emissions Management Consortium) recently agreed to buy 2.8 million tonnes of carbon dioxide-equivalent emission reduction credits from farmers in Iowa (some $6 million of CERCs from 100 farmers at a value of $7.4 per hectare).

[13] Zero tillage (ZT) had a much wider effect than just on soils. In the early days, there was a widespread belief that ZT was only for large farmers. That has now changed. A core element of ZT adoption in South America has been adaptive research – working with farmers at microcatchment level to ensure technologies are fitted well to local circumstances. *"ZT has been a major factor in changing the top-down nature of agricultural services to farmers towards a participatory, on-farm approach"*(Landers, 1999). In Brazil, some 200,000 farmers are members of the Friends of Land clubs, with some 8-10,000 groups formed. These comprose many types: from local (farmer micro-catchment and credit groups), to municipal (soil commissions, commercial farmers, farm workers), to multi-municipal (farmer foundations), to river basin (basin committees for all water users), and to state and national level (state ZT associations and national ZT federation).

Pest Control with Minimal or Zero Pesticides

5.46 Many sustainable agriculture projects have reported large reductions in pesticide use following the adoption of IPM through farmer field schools in rice agroecosystems. In Vietnam, 2 million farmers have cut pesticide use from 3.4 to 1 sprays/season; in Sri Lanka, 55,000 farmers have reduced use from 2.9 to 0.5/season; and in Indonesia, 1 million farmers have cut from 2.9 to 1.1/season. In Bangladesh, 80% of the 150,000 farmers using such integrated pest management now no longer use any pesticides. In all cases, rice yields have not fallen (Evelleens et al, 1996; Heong et al, 1999; Desilles, 1999; Jones, 1999).

5.47 Some projects are reporting that large numbers of farmers are now farming rice entirely without pesticides, such as 40% of the farmers in the Mekong Delta in Vietnam, and in parts of the Philippines, 75% use no pesticides on rice and vegetables. These changes imply considerable shifts for both farmers and professionals in the way they conceive agriculture and its routes to success.

5.48 In Vietnam, researchers recommended a simple message to farmers – cut out all insecticide use in the first 40 days of rice growth, as evidence had shown that damage had no economic effect on yields. Farmer field schools were used to get the message across to 100,000 farmers, but the spread of this practice to more than two million farmers came from a novel media campaign to change practices. The result was a shift from an average 3 to 1 pesticide sprays per season (Heong et al, 1999).

5.49 Novel research in East Africa has identified the pest management benefits of some farm biodiversity. Researchers from ICIPE and IACR-Rothamsted have found that the chemical cues (semiochemicals) produced by maize when fed upon by stem borers, and which cause increased foraging and attack by parasitic wasps, are also released by a variety of grasses (Pickett, 1999; Khan et al, 2000). Working closely with farmers, they have identified a variety of `push-pull' technologies that repel stem borers from maize, and attract them to forage grasses, particularly napier, sudan and molasses grass[14]. They have also found that the legume, silverleaf (*Desmodium*) repels stalk borers as well as having an allelopathic effects on the parasitic witchweed, *Striga hermonthica*. In western Kenya, 2000 farmers have adopted the *`vutu sukuma*' system (push-pull), with the result that maize yields have improved by 60-70% in 1998-99.

5.50 A recent study of crop heterogeneity in Yunnan, China has shown the value of mixtures of rice, both in reducing disease incidence and increasing yields (Zhu et al, 2000; Wolfe, 2000). Researchers working with farmers in ten townships on some 5350 hectares encouraged farmers to switch from growing monocultures of sticky rice to alternating rows of sticky rice with hybrids. The sticky rice brings a higher price, but is susceptible to rice blast, which is generally controlled through applications of fungicides. But planting mixtures in the same field reduced blast incidence by 94% and increased total yields by 89%. By the end of two years, it

[14] Napier grass (*Pennisetum purpureum*); sudan grass (*Sorgum* sudanensis); molasses grass (*Melinus minutiflora*).

was concluded that fungicides were no longer required. As Wolfe (2000) puts it: *"varietal mixtures may not provide all the answers to the problems of controlling diseases and producing stable yields… but their performance … merits their wider uptake"*.

Making Better Use of Water

5.51 At present, irrigated land globally accounts for about 20% of arable land, and contributes some 40% of all crop production. FAO (2000) projects the area of irrigated land to grow by 23% to 2030 – from 197 to 242 million hectares. But such an increase will depend upon a significant increase efficiency of water use.

5.52 Water is a clear constraint in many rainfed contexts and, when better harvested and conserved, may be the key factor leading to improved agricultural productivity through increased yields, allowing new lands to be brought under farming, and increased cropping intensity on existing lands.

5.53 Water harvesting can lead to improved production in both drylands and extra crops in wetlands. In the Himalayas, in one village in the Doon Valley Integrated Watershed Development programme, water harvesting led to 30 ha being irrigated during the dry season, so producing an extra rice crop. One farmer was reported as saying: *"Earlier there were fights daily over the sharing of water, but today there is absolutely no need"*. The same effect has been reported in Tamil Nadu, where watershed improvements have led to single villages of 30 households producing an extra 50 tonnes of rice per year through a doubling of cropping intensity (Devavaram et al, 1999; Thapliyal et al, 1999).

5.54 Improved water management in irrigated systems can also make a difference to outcomes. In Gal Oya in Sri Lanka, where water users groups had been established in the 1980s on some 26,300 hectares, the value of social capital was showed in 1998 during a drought. According to the government, there was only enough water for irrigation of 4900 ha of rice, but farmers persuaded the Irrigation Department to let the water through and they would carefully irrigate the whole 26,300 ha. Through cooperation and careful management, they achieved a better than average harvest, worth some $20 million to the country as a whole (Uphoff, 1999).

Adding Value and Marketing - the Forgotten Components

5.55 The empirical evidence indicates quite clearly that there is relatively little attention to adding value and / or marketing in sustainable agriculture projects (only 12-15% of the 208 projects).

5.56 A variety of options are available to increase the returns to families from their production, either by reducing losses to pests (better storage and treatment) and inefficient processes (eg fuel-saving stoves); or by adding value before sale or use (conversion of primary products through processing). The options include post-

harvest technologies; processing primary produce before sale (eg dried fruit, chutney, oil press, sawmills); labelling produce (location or eco-labels); fuel-efficient stoves.

5.57 Adding value through direct or organised marketing may involve improvements to physical infrastructure (eg roads, transport); or through direct marketing and sales to consumers (thus cutting out wholesalers and `middlemen'). The options include rural roads and infrastructure; producer groups for collective marketing; ethical trading schemes to ensure value reaches rural communities and livelihoods; green tourism schemes (selling the landscape and wildlife functions of farms).

5.58 Given the earlier discussion about significant elasticity of household food consumption, this lack of focus on marketing and value-added may be logical. But we believe this is an area that needs greater priority, as much can be done to increase incentives for farmers to increase productivity, or to sustain existing increases.

Confounding Factors, Trade-Offs and Winners-Losers

5.59 A more sustainable agriculture which improves the asset base can lead to rural livelihood improvements. People can be better off, have more food, be better organised, have access to external services and power structures, and have more choices in their lives.

5.60 However, most contexts will see the emergence of critical trade-offs and contradictions. The use of one asset can result in the depletion of another – building a road near a forest can mean loss of natural capital, as it aids timber extraction; investing in motorised fishing boats means increased capacity to harvest fish (unless, in both cases, there is strong social capital in the form of institutions to mediate access and ensure sustainable levels of offtake).

5.61 This is not to say that depletion of one asset is always undesirable – it may be in the national and local interests to convert part of a forest into finance, if that money is to be used for investment in hospitals and schools, effectively producing a transfer from natural to social and human capital. Equally, short-term social conflict may be a necessary means to overcoming inequitable land ownership, so as to produce higher welfare outcomes.

5.62 In some cases, progress in one component of a farm system may cause secondary problems. For example, projects may be making considerable progress on reducing soil erosion and increasing water conservation through adoption of zero-tillage, but still continue to rely on applications of herbicides. In other cases, improved organic matter levels in soils may lead to increased leaching of nitrate to groundwater.

5.63 There are a variety of secondary problems that may arise in sustainable agriculture projects. These include:

i) land having to be closed off to grazing for rehabilitation, resulting in people with no other source of feed having to sell their livestock;
ii) increased household workload, the burden particularly falling on women, if cropping intensity increases or new lands taken into cultivation;
iii) additional incomes arising from sales of produce may go directly to men in households, who are less likely than women to invest in children and the household as a whole.

5.64 There are also a variety of confounding factors that could make sustainable agriculture `successes' less favourable:

- Sustainable livelihoods based on sustainable agriculture may be marketing foodstuffs into an increasingly globalised world food system, in which the transport externalities (the negative impacts on atmospheric composition through carbon dioxide emissions) outweigh any localised asset-building;

- Sustainable livelihoods based on sustainable agriculture which increases the assets base may simply increase the incentives for more powerful interests to take over, such as landlords taking back formerly degraded land from tenants who had adopted sustainable agriculture;

- Sustainable livelihoods based on sustainable agriculture may appear to be keeping people in rural areas away from centres of power, and `modern' society - some rural people's aspirations may precisely to be to gain sufficient resources to leave rural areas;

- Sustainable livelihoods based on social capital formation and the emergence of significant social movements may represent a threat to existing power bases, who in turn are likely to seek to colonise locally-based institutions;

- Increasing numbers of livestock will mean more methane production, so enhancing climate change; currently livestock produce 79 million tonnes of methane, but this is predicted by FAO (2000) to increase to 128 million tonnes by 2030;

- Barriers to entry may increase as existing adopters of sustainable agriculture may seek to prevent others from benefiting.

5.65 There will also be new winners and losers with the emergence of sustainable agriculture on a significant scale. This model for farming systems implies a limited role for agro-chemical companies, who would not be predicted to accept such losses of market lightly.

5.66 It also suggests greater decentralisation of power to local communities and groups, combined with more local decision-making. This means reduced opportunities for rent-seeking and other forms of corruption from officials in private and public organisations. Research and extension agencies will have to change too, adopting

more participatory approaches to work closely with farmers, and so must adopt different measures for evaluating job success and the means to promotion.

5.67 But even if the intention is present for the development of more sustainable agriculture, there are still many threats to overcome or avoid if it is to succeed and spread. These include lack of land tenure or security, civil disorder and wars, institutional inertia, the backlash from potential losers, macro-economic decline of countries or regions, and continued climatic change and disruption.

5.68 The globalisation of world agriculture will provoke further changes. More control of the world food systems will be centralised in fewer and larger private companies. This centralisation could be good, with companies influencing whole supply chains, but is only likely to happen if companies have good ethical and sustainable bases for operations. The effects on small farmers are more likely to be severe than beneficial.

5.69 In some cases, the global nature of markets can undermine sustainable agriculture systems, with farmers rapidly shifting away from sustainable practices to exploit a short-term opportunity (such as in the Philippines, where farmers switched away from new IPM practices to grow cabbages for a new distant market). Farmers may take advantage of such cash crop opportunities at the expense of food security. In Mumias Diocese, Kenya, farmers switched to sugar cane cultivation for a local factory, but lost out on food. But a sustainable agriculture project is now helping them to increase food production through biointensive gardens. Domestic markets can be rapidly lost to cheap imports from countries externalising some of the real costs of production - such as European countries exporting milk products to India.