Chapter 4. Empirical Findings of SAFE-World Project

Summary of Projects/Initiatives on Database

4.1 At the end of the year 2000, the sustainable agriculture database contained information on 208 cases from 52 countries. This is the largest known survey of worldwide sustainable agriculture.

4.2 In these projects/initiatives, some 8.98 million farmers have adopted sustainable agriculture practices and technologies on 28.92 million hectares. As there are some 960 million hectares of land under cultivation (arable and permanent crops) in Africa, Asia and Latin America, sustainable agriculture is present on at least 3.0% of this land[1].

4.3 This aggregate figure, however, hides the fact that most of the farmers are small farmers, and most of the area is on large farms:

i) there are some 8.64 million small farmers practising sustainable farming on 8.33 million hectares;

ii) there are 349,000 larger farmers in Argentina, Brazil and Paraguay farming with zero-tillage methods on 2.59 million hectares.

4.4 The largest country representations in the database are India (23 projects/initiatives); Uganda (20); Kenya (17); Tanzania (10); China (8); the Philippines (7); Malawi (6); Honduras, Peru, Brazil, Mexico, Burkina Faso and Ethiopia (5); and Bangladesh (4).

4.5 The projects and initiatives range very widely in scale - from 10 households on 5 hectares in one project in Chile to 200,000 farmers on 10.5 million hectares in southern Brazil. Figure 4 illustrates the cumulative frequency of occurrence of projects/initiatives by numbers of farmers and by hectares of land.

4.6 We also show each of the projects in the three continents according to the number of farmers against area under sustainable agriculture (Figure 5) and the proportion of projects falling into each size class (Figure 6).

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[1] Total arable land comprises some 1600 million hectares in 1995/97, of which 388 million ha are in industrialised countries, 267 million ha in transition countries, and 960 million ha in developing countries (FAO, 2000). This 1.6 billion ha is about 11% of the world's land surface (13.4 billion ha). Some estimates suggest there are an additional 2.1 billion ha with crop production potential – but use of this for food production would cause significant losses in services for natural capital, such as wild foods, forest products, storm protection, and climate change mitigation.

4.7 Using project records, we estimate that the area under sustainable agriculture a decade ago was no more than 100,000 hectares. This is because of a combination of increased incidence of sustainable agriculture projects with increased likelihood of success. Project staff and farmers have been able to achieve localised success, and then to spread the principles and practices to much larger numbers of people, particularly where the policy context has become supportive.

4.8 The greatest spread has occurred in southern Latin America, with the adoption of Zero or No-Till farming combined with legumes as green manures and cover crops in Argentina, Brazil and Paraguay. Some 30% of all agricultural land in Brazil is now under Zero-Tillage - a remarkable expansion arising almost entirely during the latter 1990s[2].

4.9 We also believe that the data collected on numbers of farmers and hectares are conservative estimates of what has been achieved, as we have not been able to access data on all significant projects and programmes. In India, for example, as many as 6 million farmers may currently be involved in watershed development with significant local social capital formation through participatory processes (from informal data collected from bi- and multilateral donors). As we have not been able to verify these data, we report on considerably less than this through localised projects. And in Central America, some commentators estimate that there are some 200,000 farmers using green manures and cover crops in maize systems, of which 10-15,000 are a result of deliberate sustainable agriculture programmes (R. Bunch, E. Holt-Gimenez, pers. comm.). We only report here on the deliberate attempts by projects/initiatives.

4.10 Other technologies are contributing substantially to sustainability, but are not included in this dataset. In India, for example, there has been very rapid growth in soyabean cultivation in the past decade, rising from some 0.04 million ha in the mid-1960s, rising to 0.5 m ha in the 1980s (average yield of 0.57 t/ha), and now 5.6 million ha (ave. yield 0.96 t/ha). This system has many benefits: increased farmer incomes and more foreign exchange (soybean exports in 1997 earned India US$ 518 million); on-farm nitrogen fixation; rural employment through soya-based agro-industry, contribution to soil fertility through organic matter addition – 0.5-2.5 t/ha of crop residues and 45 kg N/ha of fixed nitrogen (equivalent to the free use of 250,000 tonnes of nitrogen fertilizers per year, and the addition of 2.8-14 million tonnes of organic matter); and rehabilitation of degraded lands.

Types of Improvements Used in Sustainable Agriculture Processes

4.11 We scored all projects/initiatives according to their use of the nine types of improvement for sustainable agriculture. These are organised according to their use of the five assets (natural, social, human, physical and financial) (Figure 7).

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[2] A growth rate comparable to the early Green Revolution, when in India, for example, the adoption of modern wheat varieties spread from 4 ha in 1964 to 4 million ha by 1972 (Swaminathan, 2000).

4.12 Each project could, therefore, have scored up to nine types of improvement (though none did). Just three projects used seven improvements – a UNDP rural development programme in Yunnan, China; a permaculture project in Nepal (Jajarkot); and a DFID-funded conservation farming and small business project in Kenya (ABLH).

4.13 A summary of the use of these nine types of improvements used in projects/initiatives is as follows:

One improvement only –	none
Two improvements -	15% of projects
Three improvements –	30% of projects
Four improvements –	28% of projects
Five improvements –	19% of projects
Six improvements –	13% of projects
Seven improvements –	2% of projects
Eight and nine improvements –	none

4.14 Figure 8 illustrates the frequency of occurrence of each of the nine improvement types. It is clear that some activities are considerably more common that others:

- 92% of all projects focused on building human capital (Type 6) and 88% on making better use of existing natural capital (Type 1);

- 55% of projects focused on building social capital through participatory processes and group formation (Type 5), and 59% on introducing new regenerative components into farm systems to improve and diversify natural capital (Type 3);

- 21% focused on intensifying a single component of the farm system for production improvements (eg kitchen and bio-intensive gardens, double-dug beds, fish ponds) (Type 2);

- 18% focused on more targeted and precise use of pesticides and fertilizers for improvements (Type 4);

- 17% included a microfinance element through savings and credit groups (Type 7);

- only 12-15% of projects were specifically concerned with adding value, either by processing or protection to reduce losses, or by direct and/or organised marketing of produce (Types 8 and 9).

4.15 These last findings about types 7-9 are significant, as clearly more attention is still being paid to on-farm and in-community improvements, rather than on finding ways to link farmers to markets and consumers, and to add value to produce. Many farm households are known to be limited by lack of access to affordable credit, and only one in six projects contain a micro-finance element.

Synergies Between Types of Improvement

4.16 What does the empirical evidence tell us about the nine types of sustainable agriculture improvements? Each type of improvement, by itself, can make a positive contribution to raising production. But, the real dividend is likely to come with appropriate combinations. As Uphoff (2000) comments with respect to the system of rice intensification (SRI) in Madagascar: *"no practice by itself makes as big a contribution to higher output as when the practices are used together. Rather than being just additive, we find a multiplicative effect"*. Synergistic effects (where the whole is greater than the sum of the parts) tend not to be captured or appreciated by reductionist methods of analysis that measure the effects of one variable at a time, whilst holding all the others unchanged parts (Cornia, 1985; Altieri, 1999; Rosset, 1999; Desilles, 1999; Uphoff, 2000).

4.17 Thus soil and water conservation that emphasises terracing and other physical measures to prevent natural resource losses is much less effective than combinations with biological methods that seek to increase the productivity of the system (eg green manures, cover crops), and finance for credit groups that reduces indebtedness of households.

4.18 A good example comes from irrigated rice systems, where a transition to more sustainable agriculture has only to date delivered relatively small increases in per hectare grain output (5-10%, but rising if farmers experiment with redesign of nutrient, water and soil management issues).

4.19 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.

4.20 There is a danger, however, in that this could sound like a call to re-establish `integrated rural development' – a now largely discredited term owing to the great expenditure on integrated rural development projects in the 1970s-1980s (Carney, 1998). The key difference, though, relates to process and who does the designing. If `integrated' systems are entirely designed (or even imposed) by external professionals with little regard to local people's needs, desires and constraints, then they are more likely to fail[3]. But if `redesign' emerges from a participatory process, then it is much more likely to be robust and sustainable.

Changes in Farm Productivity

4.21 We found improvements in food production are occurring through one or more of five mechanisms:

i. intensification of a single component of farm system (with little change to the rest of the farm) - such as home garden intensification with vegetables and/or tree crops, vegetables on rice bunds, and introduction of fish ponds or a dairy cow;

ii. addition of a new productive element to a farm system, such as fish or shrimps in paddy rice, or agroforestry, which provides a boost to total farm food production and/or income, but which do not necessarily affect cereal productivity;

iii. better use of natural capital to increase total farm production, especially water (by water harvesting and irrigation scheduling), and land (by reclamation of degraded land), so leading to additional new dryland crops and/or increased supply of additional water for irrigated crops (so increasing cropping intensity);

iv. improvements in per hectare yields of staples through introduction of new regenerative elements into farm systems (eg legumes, integrated pest management);

v. improvements in per hectare yields through introduction of new and locally-appropriate crop varieties and animal breeds.

4.22 Thus a successful sustainable agriculture project may be substantially improving domestic food consumption or increasing local food barters or sales through biointensive gardens or fish in rice fields, or better water management, without necessarily affecting the per hectare yields of cereals. The most common mechanisms were yield improvements with regenerative technologies or new seeds/breeds, with 60% of the projects, 56% of the farmers and 89% of the area.

4.23 Home garden intensification occurred in 20% of projects, but given its small scale only accounted for 0.7% of area. Better use of land and water, giving rise to increased cropping intensity, occurred in 14% of projects, with 31% of farmers and 8% of the area. The incorporation of new productive elements into farm systems, mainly fish and shrimps in rice, occurred in 4% of projects, and accounted for the smallest proportion of farmers and area.

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[3] Roland Bunch (pers. comm. Jan 2000) makes an important observation with respect to integrated programmes – they can be successful, but only if things are allowed to happen in local people's own good time, when they are ready: "*What I'm saying here is that pacing, and how many different things you try to do at once, is the key to successful integrated development*".

4.24 As mechanisms 4 and 5 are the most common, we analysed these in greater detail. The dataset contains 89 projects (139 entries of crop x projects combinations) with reliable data on per hectare yield changes with mechanisms 4 and 5 (Figures 9a and 9b). These illustrate that sustainable agriculture can lead to substantial increases in per hectare food production through mechanisms 4 and 5 above. The relative yield increases are greater at lower yields, indicating greater benefits for poor farmers, and for those missed by recent decades of modern agricultural development.

4.25 These two figures show relative increases in per hectare productivity in every project/initiative, with 9b an expansion for just yields below 2000 kg/ha. This indicates quite clearly that sustainable agriculture can lead to substantial increases in per hectare food production. The proportional yield increases are generally:

- 50-100% for rainfed crops, though considerably greater in a few cases;
- 5-10% for irrigated crops, through generally starting from a higher absolute yield base.

4.24 All the data in Figure 5b are from rainfed crops. A total of 33 out of the 61 data points occur within the range 0-50% increases in yields, and 28 in the 50-100% range.

Changes in Food Production per Household

4.25 We have calculated for those 96 projects with reliable data on yields, area and numbers of farmers the marginal increase in food production per household (Table 6). We have separated out the four entries for large commercial farmers in Latin America (Argentina, Brazil, Paraguay) from the remaining farms with average sizes of less than five hectares. We have also separated root crops from the remainder.

4.26 The evidence shows that:

i) for the 4.42 million farmers on 3.58 million hectares, food production per household increased by 1.71 tonnes per year (an increase of 73%);

ii) for the 146,000 farmers on 542,000 hectares cultivating roots (potato, sweet potato and cassava), the increase in food production was 17 tonnes per year (an increase of 150%);

iii) for the larger farms in Latin America (ave = 90 ha/farm), total production increased by 150 tonnes per household (an increase of 46%).

4.27 Figure 10a illustrates the increase in household food production against farm size for small farms and non-root crops, and Figure 10b gives details for those farms under 1.5 ha in size. Food production per household increases at a rate of 1.27 times area (minus a constant of 0.07). Figure 10c illustrates the increases for those 146,000 households with root crops – and here the relationship shows an increase in root production of 14.3 times farm area (less the constant of 1.76).

4.28 These improvements in both yields and household food production raise an important question: why have these effects not yet been seen in national statistics? We suggest there is significant `elasticity of food consumption' in most rural and poor urban households. Increased food production is being consumed locally (either in farm households or bartered / sold into local markets), with substantial positive benefits for child and adult health. This could be in the form of more meals per day, and / or more protein, vegetables and milk in the diet[4].

4.29 Such improvements could result in children being more able to attend school regularly and to concentrate better, and adults being able to work more productively. Only when this currently unmet demand has been largely met will we see these increases in productivity feeding through significantly into the national or even international markets.

Effects of Changes in Productivity on Household Food Security

4.30 There have been many attempts to develop single currency units to aggregate the production of many different components of farms. These include energy accounting (reducing produce to calorific value); economics (reducing produce to monetary value, including the external environmental effects); family food budgets (kg of cereal equivalent); and cropping intensity or land-equivalent ratios (to describe total annual produce from a given land area). None of these is sufficient to describe the complexity and diversity of produce from a typical small farm, nor to describe or measure food security. How is it possible to compare the total produce of one rice field with that from another containing fish?

4.31 A rural household needs the following to be food secure:

i) an adequate supply of food, either grown on the farm or bought with earned income, and measured in kcal or kg of cereal equivalent;

ii) a variety of food containing the necessary mix of protein, carbohydrate and fat, together with vitamins and minerals, for a healthy diet;

iii) the appropriate quantity and diversity throughout the year, particularly during months of shortage and / or insecurity.

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[4] It is also true that national statistics are widely believed to be very unreliable.

4.32 Most sustainable agriculture projects and initiatives report significant increases in food production - some as yield improvements, and some as increases in cropping intensity or diversity of produce. Much fewer, however, report surpluses of food being sold to local markets. We suggest that this is because of a significant elasticity of consumption amongst rural households experiencing any degree of food insecurity. As production increases, so domestic consumption also increases, with direct benefit for health, particularly of women and children.

4.33 As indicated earlier, for an average farm size of 1.4 ha (for the 4.4 million households for which good data exists), the annual increase in gross food production (not including root crops) has been 1.71 tonnes with the adoption of sustainable agriculture. The net amount of food available to each household will, of course, be lower than this – owing to post-harvest losses to pests, conversion of harvested crops to consumable food, and feeding of some as feed to animals. Assuming a worst case of 30% loss to pests, and a further 30% reduction in available food, this still leaves 800 kg of available food per household. This is sufficient to feed two adults or one adult with two children for a whole year.

4.34 It is important to note that these aggregate figures do not account for the benefits of increased diversity in the diet as well as quantity. Most of the sustainable agriculture projects/initiatives have seen great increases in farm diversity. In many cases, this translates into increased diversity of food consumed by the household, including fish protein from rice fields or fish ponds, milk and animal products from dairy cows; poultry and pigs kept in the home garden; and vegetables and fruit from home gardens and farm micro-environments.

4.35 Take a typical household of six - 2 parents, 1 grandparent, 3 children. They would be expected to consume some 1500-2100 kg of cereal equivalent per year to meet basic needs. If we assume a three-month period of severe food insecurity (where consumption was only 20% of normal), this would mean an annual reduction in consumption of 300-420 kg. This would then need a 20% increase in net food production (after post-harvest losses) to offset this food gap. If food production were to increase by 20%, then this family would eat it all. As we have shown in the empirical data, average food production is greater than this.

4.36 Further elasticity would be expected for food insecure households with new access to protein (eg from fish in rice fields or garden ponds, and from milk from dairy cows) and vegetables (eg from kitchen gardens).

4.37 Despite this, several projects have reported surpluses and regional improvements to food production. In the Ansokia Valley, Ethiopia, a programme for sustainable agriculture increased food production from 5600 to 8370 tonnes in six years, at the same time as the population had increased from 36,000 to 45,000. Per capita food production, therefore, rose from 141 to 186 kg/person. The project turned around an annual food regional deficit of -2106 tonnes to surplus of 372 tonnes/year.

4.38 In Bushenyi, Uganda, formerly experiencing substantial food shortages during October to December, a project had increased banana and cattle production to the point that the region was now selling 330 tonnes bananas and 2.7 tonnes of meat each week. In En Nahud, Sudan, the 10,000 tonnes of extra food produced for 15,000 households was all consumed by local people. None found its way into national statistics.

4.39 Once again, though, we want to emphasise the extraordinary productive potential of small patches on farms, and the degree to which they can improve domestic food security. Shah's (1997) study of agricultural improvements in Tigray identified opportunities substantially to increase food production by enhancing the biological productivity of whole catchments, and in particular by focusing on microenvironments (gardens and patches in watersheds): *"these areas have the potential to produce surpluses"*.

4.40 These areas can also see productivity increase over time, as the natural and human capital assets increase. The temporal issue is important. If agricultural systems are low in capital assets (either intrinsically low, or have become low because of degradation), then a sudden switch to `more sustainable' practices that has to rely on these assets will not be immediately successful – or at least not as successful as it might be.

4.41 In Cuba, for example, urban organic gardens (*autoconsumos*, *organoponicos* and *huertos intensivos*), produced 4200 tonnes of food in 1994. By 1999, they had greatly increased in number as well as in per area productivity – rising from 1.6 kg/m^2 to 19.6 kg/m^2, to produce some 727,000 tonnes of food (Murphy, 1999).

4.42 Increasing productivity over time has been noted in fish ponds in Malawi. These are typically some 200-500 m^2 in size (0.02-0.05 ha). Researchers compared the performance of 35 fish ponds over six years: in 1990 yields were 800 kg/ha, but rose steadily to 1450 kg/ha by 1996. This is because fish ponds are integrated into a farm so that they recycle wastes from other agricultural and household enterprises, leading to steadily increasing productivity over time. *"As farmers gain a greater understanding of how this new system functions, and an appreciation of its potential, they become increasingly able to guide further evolution towards increasing productivity and profitability"* (Brummet, 2000). But where non-participatory approaches had been used to work with farmers, yields had fallen.

Differentiated Effects on Food Production in 13 Agroecosystems

4.43 In order to understand the changes in food production occurring within these sustainable agriculture projects, we have divided the world's farm systems into 13 major types of agroecosystems (cf Ruthenburg, 1979). In each of these systems, we summarise the current situation, the kinds of improvements achieved with sustainable agriculture (if any), and the challenges for further improvements. We show the yield changes for each major crop in Figure 11.

4.44 We present selected project data in tabular form in Annex C, together with an extended analysis of current conventional systems and the changes recorded with sustainable agriculture. The 13 agro-ecosystems are shown in Table 7, with details of the proportion of projects in this study containing each type of system.

I: Wetland rice

4.45 There have been four major changes to rice agroecosystems achieved with sustainable agriculture:

i) farmer field schools leading to the adoption of agro-ecological IPM, with sharp reductions in pesticide use and small increase in rice productivity (some evidence of 30% increases when whole system management addressed);

ii) introduction of fish, crabs, prawns into rice fields, so increasing protein production, but also improving nutrient recycling and disease control;

iii) social capital formation in farmers' water users groups, leading to more equitable water management and distribution, as connected individuals and groups with strong relations of trust are able better to share water, especially during scarcities;

iv) the system of rice intensification, developed first in Madagascar, and based on wide spacing of plants, regular weeding, transplanting of immature seedlings, and water stress and aeration of soils rather than flooding during growing, leading to typical yield growth from 2 to 8t/ha.

4.46 In these systems, there are generally only small increases in per hectare productivity of rice (excepting the SRI). But total system productivity does increase when fish and vegetables are added to the system. There are further health benefits from substantial reductions in pesticide use.

4.47 These improvements are promising, but further productivity increases are likely to have to come from come from i) application of biotechnology to aid rice breeding; ii) better soil and nutrient management; iii) whole system redesign (such as the system of rice intensification).

II: Arid and semi-arid millet and sorghum

4.48 There have been two key changes to millet/sorghum agroecosystems achieved with sustainable agriculture:

i) use of a wide variety of water harvesting methods that either improve cereal yields on existing farmland, or lead to new crops in land formerly abandoned or thought no longer to be productive;

ii) soil fertility improvements, through organic matter additions (animal manures and composts); together with soil conservation methods, leading to better nutrient availability and water retention and rock phosphate amendments.

4.49 In these arid and semi-arid systems, there have been substantial increases in per ha cereal productivity, combined with large increases in total system production, leading to substantial improvements in household food availability.

4.50 However, the greatest challenges in these system after securing water for crops remains the provision of adequate nutrients and organic matter. Farmers in arid and semi-arid areas do not have many options. They need to improve organic matter in soils, yet water stresses and existing levels makes this very difficult. Importing nutrients, either through rock phosphate or inorganic fertilizers may be the only way in the long-term to ensure the sustainability of production. In the short-term, more livestock can help to recycle nutrients, and leguminous crops can fix nitrogen.

III: Rainfed maize, wheat, rice and legumes (uplands, dryland)

4.51 There have been four changes to rainfed maize, wheat and rice agroecosystems with sustainable agriculture:

i) multiple cropping of legumes (eg velvetbean, jack bean) into maize, or incorporation into rotations as cover crops and / or green manures, or as a weed suppressant;
ii) agroforestry with maize / rice for soil nitrogen-fixing and phosphate-releasing;
iii) biological control of pests, particularly using functional biodiversity, such as the semiochemicals released by some grasses that push-pull predators, parasites and pests;
iv) watershed and catchment management programmes leading to whole system change.

4.52 There is extensive evidence to indicate that sustainable agriculture can lead to: i) substantial increases in per hectare cereal production, typically up 50-100%, and in some projects rising to 200% increases; ii) increases in diversity of systems - as cereal productivity increases, so commonly farmers reduce the area under cereals and increase diversity of alternative crops and animals, such as vegetables, fruit and livestock. There are many challenges, including in particular, improving understanding of functional biodiversity and soil health, so as to make better use of available resources in systems, and developing agroecosystems that improve nutrient (particularly P and K) availability.

IV: Wheat and maize intensive rotations

4.53 Wheat and maize rotations have seen two types of improvements:

i) adoption of zero-tillage, usually combined with of cover crops and green manures, leading to 10-30% improvements in yields, and also bringing substantial benefits for the environment through reduced soil erosion and increased carbon sequestration in soil organic matter.

ii) participatory plant breeding, with substantial benefits when farmers' groups are engaged in varietal testing and experiments.

4.54 Again, these improvements are promising, and show the benefit both of close participation between professionals and farmers, and of diversified agroecosystems.

V: Home Gardens and Microenvironments (include. dairy)

4.55 Homegardens are productive because they are a focus for resources, particularly human labour and knowledge, nutrients and organic wastes, and water. They can also be an important source of livestock products, with small farmers or even landless households often owning 1-2 dairy cows, a few chickens, or a pig or goat. In addition, other micro-environments on the farm, such as gully fields and silt traps, can be highly productive.

4.56 The key changes in sustainable agriculture projects focusing on homegardens:

i. Bio-intensive gardening and double-dug beds for year-round vegetable and fruit production;
ii. Dairy cow per family, with increase in domestic milk consumption and income;
iii. Other livestock, such as chickens, pigs;
iv. Micro-environment development (more often an accidental rather than explicit part of agricultural development programmes);
v. Multi-layer tree gardens with root crops at ground level;
vi. Fish ponds in gardens.

4.57 All these mechanisms lead to substantial increases in domestic food production for households, with particular benefits for the health of women and children, and increases in women's incomes where surpluses can be sold. In many cases, food supply is now guaranteed throughout the year, whereas previously families might have had to suffer several months of deficit (such as in winter in Swaziland, or the dry season in Kenya).

4.58 The challenges centre on encouraging agricultural development programmes to focus on these very productive patches, and to consider home gardens as vital part of agricultural strategy, not something to be ignored. In addition, more research is needed to understand the potential beneficial synergies between farm components and homegardens.

VI. Tropical Roots and Tubers

4.59 Only 7% of projects in the dataset contained changes to tropical roots and tubers. The key changes with sustainable agriculture include varietal selection and testing by farmers; and IPM with farmer field schools for pest management. Although there was relatively little data on these systems, it appears that substantial improvements in tropical root production are possible through adoption of sustainable agriculture with cassava and sweet potato yields up 2-3 fold. We do not draw conclusions from these systems owing to the small sample size.

VII. Banana and Plantains as Staples in Mixed Systems

4.60 Bananas and plantains are staples in some agroecosystems, particularly in East Africa. Once again, the sample size is small (2% of projects), but these do show promising productivity improvements in the smallholder sector. Yields have increased 100-200%, changing situations of household food deficit to surpluses. Most changes have occurred through better soil and nutrient management, including use of green manures and cover crops, though the future is expected to see benefits from novel breeding methods leading to nematode-resistant varieties.

VIII. High mountains

4.61 In the high mountains, sustainable agriculture projects have focused primarily on improvement to potato cultivation through legume incorporation, raised fields for frost tolerance, and farmers' experiments and varietal testing. These have led to yield improvements of some 40-60%, rising to 200% in some cases.

IX. Livestock - extensive grasslands

4.62 Extensive pastoral systems have not formed a part of this study, even though they are an important agroecosystem to many people.

X. Livestock - intensive pasture and feed-based systems

4.63 Intensive livestock systems have not formed a part of this study. They are mostly situated in industrialised countries, though are expected to spread as demand for livestock products increases. Demand for grain for such systems could be slowed through programmes to increase feed conversion in animals (eg by modification of gut bacteria, of crops or even the animals themselves), or through adoption of knowledge- and management intensive rotational grazing systems, which make much more productive use of pastures.

XI. Intensive Horticulture and Orchards

4.64 Although intensive horticulture and related systems are of vital importance as sources of income for some farmers in some countries, as well as being large consumers of pesticides and fertilizers, they have not formed a part of this study.

XII. Fibre Crops

4.65 Some 4% of projects on the database contain details of changes to cotton production with adoption of organic methods of production. Only 0.04% of world cotton production is organic, and though yields are considerably lower in industrialised countries, they are equivalent to conventional or rise from much lower bases in organic cotton projects in Africa and India.

XIII. Plantation and Estate Crops

4.66 These are of vital importance to many households in certain countries, both as growers and as workers on estates and plantations. Most of these crops do not form a part of this study, with the exception of organic and sustainable smallholder coffee production in Mexico and Kenya. Coffee yields can increase substantially with sustainable agriculture - typically rising by 100%.

Summary

4.67 We summarise the findings from the database in Table 8. This shows the effects on productivity of key foods in projects where there is reliable data; presence of additional productive components of agroecosystems, leading to growth in total farm production; and effects on the wider environment of changes to more sustainable production systems.

Reasons for Success and Limits to Spread

4.68 We analysed the completed questionnaires and project data to explore:

i) stated reasons for success in projects and initiatives;

ii) limits and constraints on the further spread of technologies, practices and approaches.

4.69 We used a common framework of seven key indicators, each of which was then subdivided, giving 17 indicators for reasons for success and 21 indicators for constraints. The seven overarching indicators were:

1. Presence / absence of appropriate methods and processes;
2. Presence / absence of enabling policies at national or regional level;
3. Presence / absence of appropriate external linkages and support;
4. Presence / absence of appropriate social and human capital;

5. Presence / absence of appropriate infrastructure;
6. Presence / absence of shocks and stresses;
7. Presence / absence of knowledge of alternative systems of production.

4.70 Table 9 illustrates the frequency of occurrence of these seven factors in the projects scored on the database. There are striking differences between the indicators. The most important reasons for success are participatory methods / processes (35%) and good external linkages and support with NGOs and government agencies (40%).

4.71 The most important constraints on further success, however, differ, with the lack of enabling policies for sustainable agriculture accounting for 20% of stated reasons; followed by lack of infrastructure, particularly markets and transport (23%), and lack of external support (33%).

4.72 We conclude that sustainable agriculture successes have been founded mainly upon:

i) appropriate technology adapted by farmers' experimentation;

ii) a social learning and participatory approach between projects and farmers;

iii) good linkages between projects / initiatives and external agencies, together with the existence of working partnerships between agencies;

iv) presence of social capital at local level.

4.73 We conclude that if sustainable agriculture is to spread to larger numbers of farmers and communities, then future attention needs to be paid to:

i) ensuring the policy environment is enabling rather than disabling;

ii) investing in infrastructure for markets, transport and communications;

iii) ensuring government agencies in particular are supportive of local sustainable agriculture projects and initiatives;

iv) developing social capital within communities and between external agencies.