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Sustainable Agriculture:
Impacts on Food Production and Challenges for Food Security

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This Gatekeeper Series is produced by the International Institute for Environment and Development to highlight key topics in the field of sustainable agriculture. 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.

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EXECUTIVE SUMMARY

Recent approaches to agricultural production and food security have failed to reduce the absolute numbers of the food insecure or to ensure environmental sustainability. But the views on how to improve global food security vary greatly and tend to focus solely on increasing food production. There are five contrasting schools of thought: the environmental pessimists; the business-as-usual optimists; the industrialised world to the rescue lobby; the new modernists; and those who advocate sustainable intensification.

Sustainable intensification of agriculture is known to offer significant opportunities to improve food production. For the first time, data from some 63 sustainable agriculture projects and programmes have been drawn together to illustrate what can be achieved. These share some common characteristics, with resource-conserving technologies and farmer-centred participatory approaches central to the process. The analysis indicates that at least 1.1 million farmers in rainfed areas have made the transition to sustainable agriculture. Most of these farmers have made substantial improvements to their per hectare crop yields, many more than doubling yields. A further 0.79 million irrigated rice farmers have substantially cut pesticide use whilst increasing yields by an average of about 10%. Sustainable agriculture, therefore, provides the opportunity to increase food production, reduce dependency on external resources, and reduce environmental degradation.

But food production is only part of the picture. Food security cannot be achieved without significant improvements to people's entitlements and access to food. Most approaches to agricultural change have, in the past, focused narrowly on production increases without addressing the broader political economic forces that shape local farming practices and access to food. Nor have they recognised the complexity and diversity that characterises most agriculturally based livelihood systems.

An important part of this new evidence is that sustainable agriculture can also enhance people's ability to acquire food and contribute to the regeneration of rural economies. There are important lessons for agricultural projects and programmes. The paper concludes by prioritising seven immediate investments needed for enhancing productivity and environmental sustainability; and seven more investments needed for ensuring that these help support entitlements for food security.

SUSTAINABLE AGRICULTURE: IMPACTS ON FOOD PRODUCTION AND CHALLENGES FOR FOOD SECURITY

Jules N Pretty, John Thompson & Fiona Hinchcliffe

Challenges for Agricultural Development

As this century draws to a close, agricultural development faces some unprecedented challenges. By the year 2020, the world will have to support some 8.4 billion people. Even though enough food is produced in aggregate to feed everyone, some 800 million people still do not have access to sufficient food. This includes 180 million children who are underweight and suffering from malnutrition.

Recent approaches to agricultural development, including food production and food security, have largely failed to reduce the absolute numbers of the food insecure or to ensure environmental sustainability. Whilst global achievements in food production have been impressive in the last 50 years, the global inequalities in food entitlements (ie., people's ability to acquire food and gain access to and control of productive resources) remain one of the biggest obstacles to achieving food security for all.

There are five contrasting schools of thought on how we should approach these challenges. (see McCalla, 1994; Hazell, 1995; Pretty, 1995a; Thompson 1995a; Pretty and Thompson, 1996, for summaries). These are outlined in the next section. Many assume that increasing food production is the only necessary condition for improving food security. It is clearly important, especially in the complex, diverse, risk-prone agriculture which characterises some of the most food insecure regions of the world, and the paper goes on to describe the contribution which sustainable agriculture can make to increasing food production. However, there is more to food security than producing more food. We go on to discuss how sustainable agriculture in its widest sense can also help to enhance rural people's entitlements and access to food.

Five Competing Schools of Thought on Agriculture and Food Security

1. *Environmental pessimists*. This group, with prominent adherents in the official aid circles and the international agricultural research agencies, contends that ecological limits to growth are being approached and will either soon be passed or have already been reached. Following a neo-Malthusian argument, these *'environmental pessimists'* claim

that populations continue to grow too rapidly, while yields of major staple crops have declined and will continue to slow, or even fall in future. They argue that, given the current state of knowledge, no new technological breakthroughs are likely; and that some agroecological systems have been too thoroughly degraded to recover. Solving these problems means making population control the first priority (cf., Brown, 1994; CGIAR, 1994; Kendall and Pimentel, 1994; Brown and Kane, 1994; Ehrlich, 1968).

2. *Business-as-usual optimists*. This group, with a strong belief in the power of the market, argues that supply will always meet increasing demand, and so recent growth in aggregate food production will continue alongside reductions in population growth. These '*business-as-usual optimists*' expect that innovations in biotechnology will sustain the growth in food output. In many countries, however, it is also expected that the area under cultivation will expand dramatically — some estimates put the increase at an extra 79 million hectares in Sub-Saharan Africa alone by 2020 (cf., Rosegrant and Agcaolli, 1994; Mitchell and Ingco, 1993; FAO, 1993; Crosson and Anderson, 1995).

3. *Industrialised world to the rescue*. This predominantly northern-based group with ties to the agrochemical industry, asserts that, for a variety of ecological, institutional and political economic reasons, developing countries will never be able to feed themselves. This group insists that the looming food gap will have to be filled by modernised agriculture based in the North. By increasing production in large, mechanised operations, this will force smaller and more 'marginal' farmers to go out of business, so taking the pressure off natural resources, which can then be conserved in protected areas and wilderness reserves. The large producers will then be able to trade their food with those who need it, or have it distributed by international agencies to provide famine relief or food aid (cf., Avery, 1995; DowElanco, 1994; Carruthers, 1993; Knutson et al., 1990).

The two remaining groups believe that significant biological yield increases are possible on existing agricultural land. They are, however, fundamentally divided over what is the most appropriate approach to achieve these increases.

4. *New modernists.* This group, led by the partnership of the Sasakawa and Global 2000 Foundations, claims that food growth can only come through high-external-input farming, either on existing Green Revolution lands or on the 'high-potential' areas that were missed by the past 30 years of agricultural development. These 'new modernists' argue that farmers simply use too few artificial fertilisers, pesticides, high-yielding seed varieties and other external inputs, which are the only way to improve yields and reduce pressure on natural habitats. They also contend that high-input agriculture is more environmentally sustainable than low-input agriculture, as the latter requires the intensive use of local resources which may be degraded in the process (cf., Borlaug, 1992, 1994a, b; Sasakawa Global 2000, 1993-95; SAA, 1995-96; World Bank, 1993; Paarlberg, 1994; Winrock International, 1994; Crosson and Anderson, 1995).

5. *Sustainable intensification*. This group advances arguments in favour of the sustainable intensification of agricultural production, on the grounds that substantial growth is possible in currently unimproved or degraded areas whilst at the same time protecting or even regenerating natural resources. Those advocating 'sustainable intensification' point to recent empirical evidence from both the North and the South to argue that low-input

(but not necessarily zero-input) agriculture can be highly productive, provided farmers participate fully in all stages of technology development and extension. They maintain that this evidence indicates that changes in the productivity of agricultural and pastoral lands is as much a function of human capacity and ingenuity as it is of biological and physical processes (cf., Pretty, 1995a, 1996b; Thompson, 1995a, 1995b, 1996; Hinchcliffe et al., 1996; NAF, 1994; Hewitt and Smith, 1995; Bunch and López, 1996; Röling and Wagemakers, 1996).

The Sustainable Intensification of Agriculture

What is Sustainable Agriculture?

The basic challenge for sustainable agriculture is to make better use of available biophysical and human resources. This can be done by minimising the use of external inputs, by optimising the use of internal resources, or by combinations of both. This ensures the efficient and effective use of what is available, and ensures that any improvements will persist, as dependencies on external systems are kept to a reasonable minimum. Sustainable agriculture seeks the integrated use of a wide range of pest, nutrient, agroforestry, soil and water management technologies. By-products or wastes from one component or enterprise become inputs to another. As natural processes increasingly substitute for external inputs, so the impact on the environment is reduced. A more sustainable agriculture, therefore, is any system of food or fibre production that systematically pursues the goals in Box 1.

Box 1. A more sustainable agriculture pursues:

- a thorough incorporation of natural processes such as nutrient cycling, nitrogen fixation, and pest-predator relationships;
- a minimisation of the use of external and non-renewable inputs that damage the environment or harm the health of farmers and consumers;
- the participation of farmers and rural people in all processes of problem analysis, technology development, adaptation and extension, and monitoring and evaluation;
- a more equitable access to productive resources and opportunities;
- a greater productive use of local knowledge, practices and resources;
- the incorporation of a diversity of natural resources and enterprises within farms; and
- an increase in self-reliance amongst farmers and rural communities.

It should be emphasised that sustainable agriculture does not represent a return to some form of low-technology, 'backward' or 'traditional' agricultural practices. Instead it implies an incorporation of recent innovations that may originate with scientists, with farmers or both. And it is not just about food production, but about increasing the capacity of rural people to be self-reliant and resilient in the face of change, and about building strong rural organisations and economies.

But precise and absolute definitions of sustainability, and therefore of sustainable agriculture, are impossible. One of the central aims of sustainable agriculture is that the approach should be flexible, and not prescribe a concretely defined set of technologies, practices or policies. This would only serve to restrict the future options of farmers. As conditions change and as knowledge changes, so too must farmers and farming communities. Sustainable agriculture is, therefore, not a simple model or package to be imposed. It is more a process of learning and adaptation (Pretty, 1995b).

Current Extent and Impact of Sustainable Agriculture

The sustainable production of food is the first pillar of food security. In this section we address two fundamental questions:

- What would happen if agricultural production systems shifted to sustainable agriculture?
- Would this mean a new threat to food security, particularly at the local level, or can current and future populations be fed by sustainable agriculture?

The Sustainable Agriculture Programme of IIED has examined the extent and impact of sustainable agriculture in a selected number of countries, and used this empirical evidence to estimate sustainable agriculture's potential contribution to global food production. Whilst we were aware that many projects and programmes had improved agricultural yields, these data have never been collated in one place. This paper represents a first attempt to analyse the impacts, especially in terms of productivity.

The government and non-government programmes and projects included in this analysis share important common characteristics. They have:

- made use of resource-conserving technologies in conjunction with group or collective approaches to agricultural improvement and natural resource management;
- put participatory approaches and farmer-centred activities at the centre of their agenda - hence, these activities are occurring on local people's terms, and so are more likely to persist after the projects and programmes have ended;
- not used subsidies or food-for-work to 'buy' the participation of local people, or to encourage them to adopt particular technologies, and thus improvements are unlikely to fade away or simply disappear at the end of projects or programmes;
- supported the active involvement of women as key producers and facilitators;
- emphasised 'adding value' to agricultural products through agro-processing, marketing, and other off-farm activities, thus creating employment and income-generating opportunities and retaining the surplus in the rural economy.

Two types of transition to sustainable agriculture have been assessed: from modern or conventional high-external input agriculture (such as farming in Green Revolution lands or in

the industrialised countries); and from traditional, rainfed agriculture where cereal yields have largely remained constant over centuries. As these transitions are recent (within the past ten years), they provide compelling evidence that similar improvements could occur elsewhere and that they could be repeated on a larger scale[1].

In the 20 countries of the South (and the total of 63 projects) examined and analysed, there are some 1.93 million households farming 4.1 million hectares with sustainable agriculture technologies and practices (Table 1).

The data in Table 1 do not represent a comprehensive survey of sustainable agriculture in each of the countries. They do illustrate, however, what has been achieved by specific projects and what could be replicated elsewhere. Most of these improvements have occurred in the past ten years (many in the past two to five years). The assumption is that these are representative of what is possible on a wider scale. It could be argued, however, that they are only successful because they have occurred where there is a combination of the least resistance and most opportunity, although the sheer diversity of approaches and contexts represented undermine such an assertion. Moreover, many of the improvements are occurring in difficult, remote and resource-poor areas that have commonly been assumed in the past to be incapable of producing food surpluses.

Impacts on Cereal Production

This analysis mainly focuses on cereal yields as an important indicator of improved performance. In all of the initiatives assessed (see Annex 1), per hectare agricultural productivity has increased — in some cases substantially. These yield improvements differ according to whether agricultural systems are in high-yielding (HY), medium-yielding (MY) and low-yielding (LY) countries[2]. There are currently 56 LY countries, 65 MY countries and 46 HY countries (countries with a very small area under cereals were not included in the analysis).

The greatest increases following a transition to sustainable agriculture are in rainfed agriculture in the lowest yield countries, where the average new yields for wheat, maize and sorghum-millet are of the order of double the yields of conventional or pre-sustainable agriculture (Table 2).

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1. We have not included in the analysis the hundreds of millions of hectares of agriculture that is commonly called 'traditional'. These systems are largely sustainable, in that they do not damage the environment. They also contribute to local communities and economies in other ways. But most are relatively unintensive, unchanged or unimproved. Their extent still dwarfs the extent of recent transitions to sustainably intensified agriculture (cf., Pretty, 1996a). In Greece, Hungary, Italy, Portugal and Spain, there are 8.1 million ha of mixed arable and livestock systems, 3.5 million ha of traditional olive groves, and 26 million ha of migratory pastoral systems. Cereal yields in these systems rarely exceed 800 kg/ha (IEEP and WWF, 1994).

2. Countries were divided into high, medium and low yielding countries for 'all cereals', 'wheat', 'rice', 'maize' and 'sorghum-millet'. High yield (HY) countries are those with yields greater than the world average; medium yield (MY) are 50-100% of world average; and low yield (LY) are those with less than 50% of world average. For all cereals, the average yield is 2.83 t/ha; for wheat 2.45 t/ha; for rice 3.05 t/ha; for maize 4.33 t/ha; and for sorghum-millet 1.09 t/ha. In all, there are 56 LY countries whose average cereal yields are less than 1.42 t/ha.

Table 1. Examples of the extent and impact of sustainable and people-centred agriculture in different agricultural systems (see Annex 1 for details of data sources and surveys)

Countries	Number of farming households reported	Number of hectares reported	Dominant crop	Yield Improvement factor (%)
RAINFED SYSTEMS				
Brazil	223,000	1,330,000	Maize, Wheat	198 to 246%
Burkina Faso	22,500	37,360	Sorghum/millet	250%
Ethiopia	24,175	21,850	Maize	154%
Guatemala	17,000	17,000	Maize	250%
Honduras	27,000	42,000	Maize	250%
India	307,910	993,410	Sorghum/Millet	288%
Kenya	222,550	250,000	Maize	200%
Mexico	7400	23,500	Coffee	140%
Nepal	3000	1300	Maize, Wheat	164 to 307%
Philippines	850	920	Upland rice	214%
Senegal	200,000	400,000	Sorghum/Millet	300%
Uganda	9426	21,379	Maize	150%
Zambia	6300	6300	Sorghum/Millet	200%
Total	**1,146,111**	**3,257,519**		
IRRIGATED SYSTEMS				
Bangladesh	11,025	4772	Rice	110%
China	47,000	12,000	Rice	111%
India	50,000	71,300	Rice	108%
Indonesia	400,000	267,000	Rice	107%
Malaysia	2500	3925	Rice	108%
Philippines	175,000	385,000	Rice	112%
Sri Lanka	100,000	95,350	Rice	117%
Thailand	500	2040	Rice	109%
Vietnam	6600	3540	Rice	108%
Total	**792,625**	**844,927**		
INDUSTRIALISED SYSTEMS				
Germany (integrated)	75,000	200,000	Wheat/Barley	90%
Netherlands (integrated)	500	na	Wheat/Barley	85%
USA (integrated)	40,000	632,000	Wheat/Barley	95%
EU (organic)	50,000	1,200,000	Wheat/Barley	80%
Total	**165,500**	**832,000**		

Note: Improvements are measured against non-sustainable farming equivalents, which are taken to be 100%. Thus an improvement of 200% implies a doubling of yields; one of 90% implies a fall in yields of 10%. The time frame for these improvements is during the life of programme activities, usually less than 5 years. Some improvements are expected to occur in the season following the adoption of sustainable agriuclture, and these tend to increase over time.

Table 2. Improvements in cereal yields up to ten years after adoption of sustainable agriculture (where conventional or pre-sustainable agriculture = 100%)

	Average Current Yields (t/ha)	Average changes in High-Yield agriculture	Average changes in medium-Yield agriculture	Average changes in Low-Yield agriculture
All Cereals	2.83	102%	166%	212%
Wheat	2.45	95%	210%	220%
Rice	3.05	115%	111%	111%
Maize	4.33	100%	190%	220%
Sorghum-Millet	1.09	95%	265%	265%

Notes:
i) data are drawn from an analysis of 1.82 million farmers on 3.43 million hectares.
ii) a figure of 102% is equal to an increase of 2%; a figure of 95% is equal to a decrease of 5%. These data clearly hide considerable variation and do not imply, for example, that cereal yields will increase by 2% in high-yield (industrialised) countries for all farmers. They illustrate the average change recorded by many farmers in many programmes.

Smaller increases have occurred in the irrigated lands of South East and South Asia (sites of the 'successes' of the Green Revolution), where productivity is already at least three to five times higher than in rainfed lands. Here sustainable agriculture rice yields are slightly more than 10% greater than in conventional or pre-sustainable agriculture.

In industrialised countries, a shift to sustainable agriculture is expected to bring a decline in productivity, as the production levels are so much higher than in most of Africa, Asia and Latin America. The immediate falls are of the order of 10-20%. The sharp declines in input costs mean, however, that these systems are still as profitable to farmers as the more conventional ones fully dependent on high use of external inputs. In the longer-term (five to ten years), evidence suggests that the yields in sustainable agriculture will rise to former levels (Faeth 1993, 1995; Hewitt and Smith, 1995).

In the USA, for example, the top 25% of sustainable agriculture farmers have better gross margins and better yields than the top 25% of conventional farmers (NAF, 1994). There are also variations over time — after conversion to sustainable agriculture in industrialised systems, yields do fall 10-20%; but many farmers find that these return to parity with conventional yields after five years or so, as their knowledge and management skills increase and as the natural capital is rebuilt.

These data indicate that the widespread adoption of sustainable agriculture would have a significant redistributive effect on productive capacity. The currently low and medium yielding countries (which are also the poorest) would benefit more in terms of food production than the high yield countries.

Why Cereal Yields Give Only a Partial Picture

Although a useful indication of what can be achieved, these data provide only a partial picture of the improvements that have occurred, or have the potential to occur, through a more sustainable approach to agriculture and rural development. Sustainable agriculture offers farmers the opportunity to diversify their strategies. For this reason, cereal production may not increase in the short term following the adoption of sustainable agriculture, as many farmers respond to increased yields by diversifying into new crops, so reducing the area under cereals.

One pattern is as follows: soon after transition to sustainable agriculture, farmers get excited by the extra productivity; in the following year, everyone is producing so much more that the local market price declines or collapses and producers get poorer returns. In the next year, they reduce the area under cereals, and diversify into new crops. This cycle has been observed in a number of contexts. In Honduras, for example, farmers who used to grow maize exclusively now cultivate upwards of 25 crops per farm; (cf., Bunch and López, 1996); in Gujarat, India, farmers have diversified away from sorghum/millet based systems to grow many types of vegetables (P. Shah, pers. comm., 1996); in Bolivia, upland potato farmers have reduced field sizes (by up to 90%) to save on labour and yet produce the same amount of food (E. Ruddell, pers. comm., 1995)

In other cases, farmers have diversified without much change to cereal production. In Taita, Kenya, an NGO reintroduced traditional staples of sweet potato, arrowroot, sugar cane and bananas, together with fruit trees and zero-grazing for livestock, leading to a reduction in food insecurity and an improvement in the nutritional status of the local population. There has been no measurable impact on cereal yields, either positive or negative (World Neighbors, reported in Hinchcliffe et al., 1996).

But this is not always the case. There are many examples of food deficit areas such as parts of Ethiopia, Kenya, Uganda, Zimbabwe, Honduras and Guatemala, becoming food surplus areas following adoption of sustainable agriculture (Hinchcliffe et al., 1996; Bunch and López, 1996). Other factors may have been important, but sustainable agriculture played a key role.

Furthermore, this analysis has not included the effect of sustainable agriculture on roots, tubers and plantains, which account for 40% of the total food supplies (in calories) for some 50% of the population of Sub-Saharan Africa, and are important staples in parts of Latin America and the Caribbean. Sustainable agriculture improvements in these agricultural systems tend to have more to do with increasing the diversity of production, rather than the productivity of these staples.

Linking Food Production and Food Security

An Entitlements Perspective

Recent years have seen many efforts to predict the increases in agricultural production needed to achieve global food security over the next quarter to half century (from, for example, IFPRI, the World Bank, FAO, the CGIAR, and the Stockholm Environment Institute[3]). These all conclude that food production will have to increase substantially over the next few decades to feed the increasing global population.

But global projections do not necessarily help when it comes to addressing food security at the local level. What is most commonly omitted is the importance of the 'entitlements' of people and the 'capabilities' these entitlements generate. Food production is not the same as food availability - this is production minus exports, and plus imports. Aggregate availability and the ability to acquire food (ie. food `entitlements') are also not the same. Whilst food production is undoubtedly among the more important influences in the determination of food entitlements, the connections are complex and many factors are important[4].

Current levels of agricultural productivity and production say little about potential levels because they are a response largely to present levels of demand and price/market conditions. As Amartya Sen (1994) observes:

> *Food is produced by ... farmers and others not to demonstrate how much can be grown, but to make economic use of it — to eat, to sell, to exchange. We cannot directly infer how much could have been produced merely by looking at what was actually produced... Food will not be produced beyond the effective demand for it.*

Thus, food production is an important part of food security, but not the only part. Some 800 million people currently have completely inadequate consumption levels and access to food. But most of these people, who would otherwise consume more, do not have sufficient incomes to demand more food and cause it to be produced.

For poor people, increased demand and increased production are part of the same equation. If production constraints limit agricultural growth, they act as brakes on both incomes and demand as well as supply. In countries with a heavy dependence on agriculture, progress towards improved food security does depend on making agriculture more productive.

This presents us with a paradox. Food security largely depends on access and entitlements to food, which depend on improved incomes for many. If incomes are increased, then more food will be produced. But for many people in many countries, increased income depends on improvements to agriculture.

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3. See IFPRI, 1995; Crosson and Anderson, 1995; FAO, 1995; CGIAR, 1994; Leach, 1995

4. For a more extensive discussion on the `entitlement approach', see Sen, 1994; and Drèze et al., 1995; for critiques, see Bowbrick, 1986; Devereaux, 1988; de Waal, 1989; Eicher, 1988.

It is clear that a strategy to enhance rural food security must also focus on creating and supporting linkages which allow increased food production to support healthy rural economies (Box 2).

Box 1. Role of agriculture in linking food production to healthy local economies

Agriculture plays a dual role in the abolition of hunger - it produces the food and it can also produce a great many of the jobs needed by households to buy food. Since agriculture is the world's single largest employer, raising productivity can immediately place additional purchasing power in the hands of the rural poor, who will in turn use the additional income for buying more food and other basic consumer goods. The increased agricultural produce can become raw material for a wide range of agro-based industries and services, stimulating the formation of new enterprises and creating downstream jobs.

Source: Swaminathan, 1995

This immediately raises several crucial questions. Which type of agriculture is best to pursue if food security is really to be taken to be an important goal?

Both the '*business-as-usual optimists'* and the '*industrialised world to the rescue'* lobby make the assumption that developing countries can rely on food imports to ensure their food security. But this may not be possible. The uncertainties of the world food market, the shortage of physical facilities to ship, process and store large volumes of food, foreign exchange constraints and high internal transport costs, all mean that an over-reliance on food imports would be inadvisable in many developing countries (Platteau, 1995, 1996). They do not explain how the poor will acquire the purchasing power to buy the food they need. Even if we assume large increases in imports, food security for millions of people in 2020 will still depend on their ability to produce their own food (Scherr, 1995).

The '*environmental pessimists'*, like the 'optimists', do not account for economic arguments that indicate that current food supply mainly reflects current demand and price conditions. In other words, food will not be produced beyond the effective demand for it (Sen, 1994).

The '*new modernists'*, in continuing to emphasise food production at all costs, fail to take account of the evidence of the detrimental impacts of high-input agriculture over the past 50 years. It has become clear that not only is this approach failing to improve food security for the most vulnerable groups, it has also been achieved at great environmental and health costs (Pretty, 1995a; Repetto and Baliga, 1996; Faeth, 1993; Conway and Pretty, 1991).

Furthermore, although recent analyses of food security have highlighted the differences between food production and food availability and access, most have failed to address fully the need for social, economic and environmental sustainability in food production. The emphasis on increasing yields has led policy makers to disregard or misunderstand how these approaches may hinder, rather than help, food security in the developing world. Sustainable agriculture offers opportunities to deal with these issues in an integrated way.

Production-Security-Natural Resource Connections

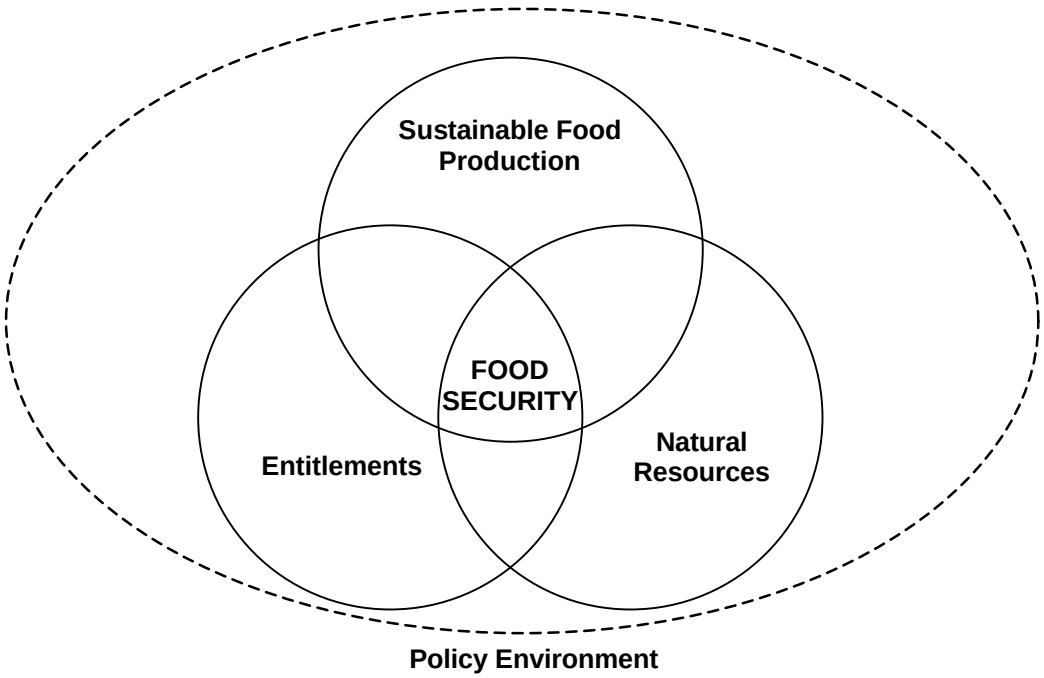
The links between sustainable agriculture and food security are summarised in Figure 1. This shows how achieving food security depends on ensuring that three key conditions are fulfilled:

- *Sustainable food production* through the use of regenerative technologies, the full participation of farmers and pastoralists in the processes of planning, research and extension;

- *A conserved natural resource base* through approaches, practices and technologies that build upon and enhance the health and diversity of available natural resources without depleting them;

- *Entitlements or access to food* through approaches which strengthen local capacity and build strong and diversified rural economies.

Figure 1. Sustainable Agriculture and Food Security: Making the Link



As the model suggests, all these areas are inextricably linked, and the achievement of sustainable food security depends on conditions being met within all three areas. It also shows that meeting these conditions depends on a supportive policy environment.

Rural Economies and the Wider Policy Environment

Improving agricultural productivity through sustainable technologies and practices can go some way toward increasing local food availability.

An important theme which emerged in one of IIED's recent surveys (Hinchcliffe et al., 1996) is that sustainable agriculture can help to contribute to revitalising and strengthening rural economies, in turn improving many people's ability to acquire food. Some examples included:

- increases in real income and establishing the capacity to save;
- employment creation and the diversification of livelihoods;
- reduced dependence on credit;
- increasing land values and greater investment on farms;
- creation of markets or improved access to markets;
- greater ability to pay school fees, hospital bills, etc.; and
- increasing confidence of people in the productive capacity of their land and in their own abilities.

But sustainable agriculture alone will not be sufficient to meet many people's food security requirements. For a host of reasons, not all rural people are able to produce their own food, and in many areas and for many people, agriculture is not the only, or even the main, source of income. Even where food supplies are adequate, absence of employment opportunities to provide income to purchase food can result in hunger (Swaminathan, 1995). In other areas, increasing population pressures have led to the complete absence of free land for development (Tiffen et al., 1994). And of course, while many farmers also migrate seasonally to supplement their incomes, most of them would rather not (Baker, 1995).[5]

An important lesson drawn from the recent evidence of sustainable agriculture is that it needs to be placed in a wider political and policy context. Strengthening other employment sources, such as small-scale enterprises, cottage industries and small-scale processing units in rural areas can help take pressure off land. This can then mitigate degradation - although this also depends on many other factors, such as land husbandry practices, access to markets, security of tenure, etc. Furthermore, if much of rural consumption depends on non-agrarian incomes and entitlements, then to concentrate exclusively on resource-conserving technologies, participatory research and development approaches and farmer-to-farmer extension will address only part of the problem.

In short, 'success' comes in many forms. It cannot be measured solely on the basis of the number of community tree nurseries, multiple cropping systems, grass strips or bench terraces

5. Even when farmers do migrate, they often take the farm to the city. In Africa, urban agriculture plays an increasingly important role in meeting food needs: see Mbiba (1995); Maxwell and Zziwa (1992); Smit and Nasr (1992); Streiffeler (1987).

that spring up across the landscape. Hence, we must make certain that agricultural policies do more than simply focus on improving productivity, while the unnoticed nutritional status of the families involved becomes yet more chronic as a consequence of other changes in the regional economy (Sahn, 1994; Thomas-Slayter and Rocheleau, 1995).

On the basis of these observations, it is clear that a strategy to enhance agricultural production and reduce rural poverty must also aim to promote rurally based non-agrarian incomes (de Janvry and Sadoulet, 1988; Bebbington, 1994; Berdegue, 1994). The essence of this would be to find mechanisms to facilitate the retention of surpluses within a region.

Such mechanisms might include new marketing arrangements and the incorporation of a processing stage to develop new forward and backward linkages within the regional agricultural system. Aside from a direct creation of employment in agro-processing, agro-industry and marketing, the resulting positive impact on farmer income would be to create a derived demand for non-agrarian goods and services that could be generated locally.

Finding the institutional mechanisms to make this work will be very difficult, but not necessarily impossible. Identifying and supporting these institutional arrangements, and helping develop the markets for the products being processed should be a central thrust of any broad sustainable agriculture policy cognisant of the realities of regional economic development.

Lessons Learned

Our conclusion from this analysis is that a shift towards more intensive, sustainable forms of agriculture can make a substantial positive contribution to food security — not only through its ability to contribute to sustainable intensification of production, but also through an emphasis on improving people's ability to acquire food.

Food deficit countries appear likely to win the most. Food exporting countries, such as the USA and those in the EU, will probably see a decline in food production in the short-term, but this is unlikely to be permanent, and financial returns to farmers should remain the same or even be improved, particularly as the levels of direct and indirect subsidies decline.

In the first instance, emphasis should not be placed on agricultural extensification (i.e. bringing more land under production), but on sustainable agricultural intensification. There is no need for agriculture to expand into uncultivated lands, as existing farmlands contain huge potential that is currently being overlooked.

A massive increase in inorganic fertilisers and pesticides is not a necessary condition for feeding the world. In certain agroecological systems, moderate applications of fertilisers will be necessary to ensure the appropriate balance of plant nutrients and minerals in soils. Pesticides will also have a place, but only in so far as they are required in carefully designed and managed integrated pest management programmes.

It also appears that increased food production will not depend on advances in biotechnology. Although biotechnology is expected by many to contribute to agriculture's productivity, and possibly to more environmentally-friendly agriculture (such as with microbial growth promoters, virus-free stocks of cassava, and nitrogen-fixing nodules on cereal roots), it will make little difference for poor farmers and farmers in low-income food deficit countries. The achievements recorded here all occurred through making the best use of locally-available resources.

Investments Needed for the Future

Sustainable agriculture represents a capital investment as it helps in natural capital formation. It replenishes the capital stock of soil nutrients, of water resources, and of predators and other beneficial wildlife. Most agriculture today progressively depletes natural and human capital, by removing soil nutrients, organic matter and water, and by diminishing human capacity and skills. Current levels of agricultural productivity are maintained by these processes of asset stripping and under-investment.

An investment in approaches and processes that help the transition to sustainable agriculture is an investment both in the current and future capacity to feed the world.

A shift to sustainable agriculture will require many different investments, if productivity and environmental sustainability are to be enhanced and if they are to be linked to food security (Hinchcliffe et al., 1996).

Seven Investments for Enhancing Sustainable Agriculture

There is a need to move beyond the high-external-input modernist approaches to agricultural development and recognise the importance of sustainable agriculture for food security, by:

1. Promoting sustainable agriculture and resource-conserving technologies and practices.

2. Supporting national policies and strategies for sustainable agriculture.

3. Redirecting subsidies and grants towards sustainable technologies and practices.

4. Reforming teaching and training establishments to encourage the formal adoption of participatory methods and processes.

5. Developing farmer-centred research and extension by supporting farmer-to-farmer exchanges and schemes for farmer training in their own communities.

6. Improving rural infrastructure to ensure access to markets with positive price incentives.

7. Improving farmers' access to and management of the diversity of wild and cultivated genetic resources.

Seven Investments for Enhancing Food Security

There is a need to focus on rural social enterprises and surplus retention by:

1. Adopting an entitlements perspective that encourages the retention of regional surpluses.

2. Focusing on improvements to non-agricultural incomes and off-farm employment.

3. Decentralising and devolving authority from governments and aid agencies, while providing local organisations with support to develop their capacity to 'draw down' resources as needed.

4. Supporting rural women as producers and facilitators by developing their access to and control of productive resources, including savings and credit, and information.

5. Supporting security of tenure for agricultural productivity, especially through indigenous systems, by reasserting community use and management rights to land that build on local rather than centralised systems of property.

6. Forming or strengthening farmers' organisations and local users' groups.

7. Supporting rural savings and credit provision by avoiding land-tied credit and supporting local savings and credit groups.

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