Reducing Food Poverty with Sustainable Agriculture: A Summary of New Evidence

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Acronyms

ABLH	Association for Better Land Husbandry
ACC/SCN	UN Administrative Committee on Coordination, Sub-Committee on Nutrition
DFID	Department for International Development
FAO	UN Food and Agriculture Organisation
FAOSTAT	FAO database
FFS	Farmer field school
GM	Genetically-modified
GMO	Genetically-modified organism
ha	hectare
ICIPE	International Centre for Insect Physiology and Ecology
IFPRI	International Food Policy Research Institute
IPM	Integrated Pest Management
MST	Movimento dos Trabalhadores Rurais Sem Terra (Landless Workers Movement), Brazil
SAFE-World	Sustainable Agriculture – Feeding the World research project
SRI	System of rice intensification
UN	United Nations
UNDP	United Nations Development Programme
ZT	Zero-tillage

Disclaimer

Reducing Food Poverty with Sustainable Agriculture

Executive Summary

The Scale of the Challenge

1. Over the past 40 years, per capita world food production has grown by 25%, and food prices in real terms have fallen by 40%. Between the early 1960s and mid-1990s, average cereal yields grew from 1.2 t/ha to 2.52 t/ha in developing countries whilst total cereal production has grown from 420 to 1176 million tonnes per year.

2. Yet the world still faces a fundamental food security challenge. Despite steadily falling fertility rates and family sizes, the world population is expected to grow to 8.9 billion by 2050. By this time, 84% of people will be in those countries currently making up the `developing' world.

3. At the year 2000, there were 790 million people hungry. Despite progress on average per capita consumption of food (up 17% in the past 30 years to 2760 kcal), people in 33 countries still consume under 2200 kcal per day. Although a combination of increased production and more imports will mean per capita consumption will increase to about 3000 kcal per day by 2015, food insecurity and malnutrition will still persist.

Changes in Demand for Food

4. Food demand will both grow and shift in the coming decades for three reasons:

   i) increasing numbers of people (until at least the mid-late 21st century) mean the absolute demand for food will increase;

   ii) increasing incomes mean people will have more purchasing power (even though many will remain on no more than $1/day);

   iii) increasing urbanisation means people will be more likely to adopt new diets, particularly consuming more meat - demand is expected to double by 2020 in developing countries, and increase by 25% in industrialised countries, helping to drive a total and per capita increase in demand for cereals (it takes 7 kg of feed to produce 1 kg of feedlot beef, 4 kg for 1kg of pork, and 2 kg for 1 kg of poultry).

Who Needs the Food the Most?

5. With gloomy predictions about increasing numbers of people, growing demand for cereals and meat, and stubbornly persistent hunger and poverty, an important question relates to who needs an increase in food the most. It is clear that adequate and appropriate food supply is a necessary condition for eliminating hunger and food-poverty.

6. But increased food supply does not automatically mean increased food security for all. What is important is who produces the food, who has access to the technology and knowledge to produce it, and who has the purchasing power to acquire it.

7. There is now increasing agreement that more attention needs to be paid to maternal and child nutrition. Low birth weight is a key factor in child malnutrition and premature death, which is, in turn, caused by a mother's poor nutrition before conception and during pregnancy. In the year 2000, 27% of pre-school children (some 182 million) in developing countries had stunted growth (where height is less that two standard deviations from the mean of the age). This is due both to poor quantity and diversity of foods, leading to widespread deficiencies of vitamins and minerals.

8. Women and children need more food – but there is also a need for better female education, family health improvements, and status improvements for women relative to men. Women are disadvantaged in agricultural systems, producing up to 80% of food, but owning little land and with access to less than 10% of credit and extension advice.

9. The conventional wisdom is that, in order to double food supply, we need to redouble efforts to modernise agriculture. After all, it has been successful in the past. But there are doubts about the capacity of such systems to reduce food poverty. The poor and hungry need low-cost and readily-available technologies and practices to increase local food production.

Choices for Agricultural Development

10. There are three possible choices for agricultural development:

- expand the area of agriculture, by converting new lands to agriculture, but with the result that services from forests, grasslands and other areas of important biodiversity are lost;

- increase per hectare production in agricultural exporting countries (mostly industrialised), so that food can be transferred or sold to those who need it;

- increase total farm productivity in developing countries which are most going to need the food.

11. The success of modern agriculture in recent decades has often masked significant externalities, affecting both natural capital and human health, as well as agriculture itself. Environmental and health problems associated with agriculture have been increasingly well-documented, but it is only recently that the scale of the costs has come to be appreciated.

12. In this research, we explore the options offered by a more sustainable agriculture, and draw some tentative conclusions about the value of increasing food production based on locally-available resources in developing countries.

13. The central issues are, therefore, i) the extent to which farmers can improve food production with cheap, low-cost, locally-available technologies and inputs, and ii) whether they can do this without causing further environmental damage.

Sustainable Agriculture – What is it?

14. A more sustainable agriculture seeks to make the best use of nature's goods and services as functional inputs. It does this by integrating natural and regenerative processes, such as nutrient cycling, nitrogen fixation, soil regeneration and natural enemies of pests into food production processes. It minimises the use of non-renewable inputs (pesticides and fertilizers) that damage the environment or harm the health of farmers and consumers. It makes better use of the knowledge and skills of farmers, so improving their self-reliance. And it seeks to make productive use of social capital - people's capacities to work together to solve common management problems, such as pest, watershed, irrigation, forest and credit management.

15. Sustainable agriculture technologies and practices must be locally-adapted. They emerge from new configurations of social capital (relations of trust embodied in new social organisations, and new horizontal and vertical partnerships between institutions) and human capital (leadership, ingenuity, management skills and knowledge, capacity to experiment and innovate). Agricultural systems with high social and human capital are able to innovate in the face of uncertainty.

16. Sustainable agriculture jointly produces food and other goods for farm families and markets, but it also contributes to a range of public goods, such as clean water, wildlife, carbon sequestration in soils, flood protection, landscape quality. It delivers many unique non-food functions that cannot be produced by other sectors (eg on-farm biodiversity, groundwater recharge, urban to rural migration, social cohesion).

SAFE-World Project Methodology

17. The aim of the SAFE-World research project was to audit recent worldwide progress towards sustainable agriculture, and assess the extent to which such projects/initiatives, if spread on a much larger scale, could feed a growing world population that is already substantially food insecure.

18. We developed a four-page questionnaire as the main survey instrument for projects/initiatives. It addressed i. key impacts on total food production, and on natural, social and human capital; ii. the project/initiative structure and institutions; iii. details of the context and reasons for success; iv. spread and scaling-up (institutional, technical and policy constraints).

19. The questionnaire was centred on an assets-based model of agricultural systems, and was developed to understand both the role of these assets as inputs to agriculture and the consequences of agriculture upon them. The questions were

also formulated with regard to the nine types of sustainable agriculture improvement identified as the conceptual base for this project (see below).

20. We collated all returned questionnaires and secondary material, and added this to the country databases. All datasets were re-examined to identify gaps and ambiguities, and correspondents contacted again to help fill these. We established trustworthiness checks by engaging in regular personal dialogue with respondents, through checks with secondary data, and by critical review by external reviewers and experts.

21. We rejected cases from the database on several grounds: i) where there was no obvious sustainable agriculture link; ii) where participation was for direct material incentives (as there are doubts that ensuing improvements persist after such incentives end); iii) where there was heavy or sole reliance on fossil-fuel derived inputs for improvement, or on their targeted use alone (this is not necessarily to negate these projects, but to indicate that they are not the focus of this research); iv) where the data provided in the questionnaire has been too weak; v) where findings were unsubstantiated by the verification process.

22. However, we have undoubtedly missed many novel, interesting and globally-relevant projects/initiatives. Just because this research project is global in scope does not mean we have been able to be comprehensive. We therefore present conservative estimates of what has been achieved, over what area, and by how many farmers.

Summary of Projects/Initiatives on Database

23. The sustainable agriculture dataset contains information on 208 cases from 52 countries. This is the largest known survey of worldwide sustainable agriculture.

24. In these projects/initiatives, some 8.98 million farmers have adopted sustainable agriculture practices and technologies on 28.92 million hectares - equivalent to 3.0% of the 960 million hectares of arable and permanent crops in Africa, Asia and Latin America. Using project records, we estimate that the area under sustainable agriculture a decade ago was no more than 100,000 hectares.

25. 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 (all 5); and Bangladesh (4). Of farms in the total dataset, 90% are in projects with a mean area per farmer of less than or equal to 2 hectares. Just four initiatives focusing on zero-tillage in Latin America account for some 20 million hectares. We also believe that the data collected on numbers of farmers and hectares are conservative estimates of what has been achieved.

26. We scored all projects/initiatives according to their use of the nine types of improvement for sustainable agriculture (see Box):

1: Better use of locally-available natural resources – 88% of projects
2: Intensify microenvironments in farm system (gardens, orchards, ponds) – 21% of projects
3: Diversify by adding new regenerative components – 59% of projects
4: Better use of non-renewable inputs and external technologies – 18% of projects
5: Social and participatory processes leading to group action – 55% of projects
6: Human capital building through continuous learning programmes – 92% of projects
7: Access to affordable finance (credit, grants, subsidies) – 17% of projects
8: Added value through processing to reduce losses and increase returns – 12% of projects
9: Adding value through direct or organised marketing to consumers – 15% of projects

27. 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.

How Farm Productivity is Increasing

28. 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);

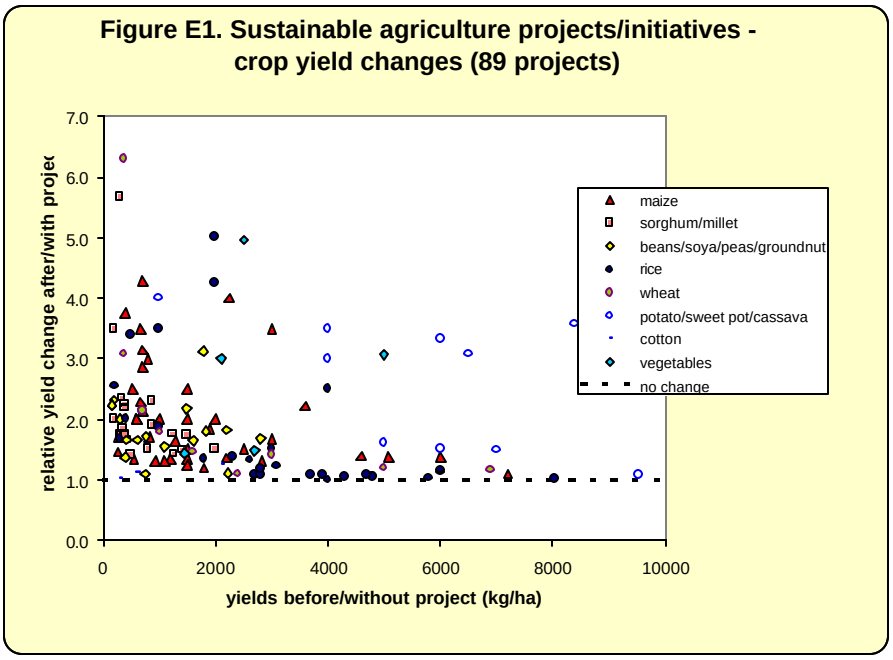
iv. improvements in per hectare yields of staples through introduction of new regenerative elements into farm systems (eg legumes, integrated pest management);

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

29. 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.

30. The dataset contains reliable data on yield changes in 89 projects (139 entries of crop x projects combinations). Figure E1 shows details of the relative increases in per hectare productivity. This indicates 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.

31. In order to understand the changes in food production occurring within these sustainable agriculture projects, we divided the world's farm systems into 13 major types of agroecosystems. 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.

Changes in Food Production per Household

32. We calculated the marginal increase in food production per household for those 96 projects with data on reliable yields, area and numbers of farmers. We 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.

33. 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.

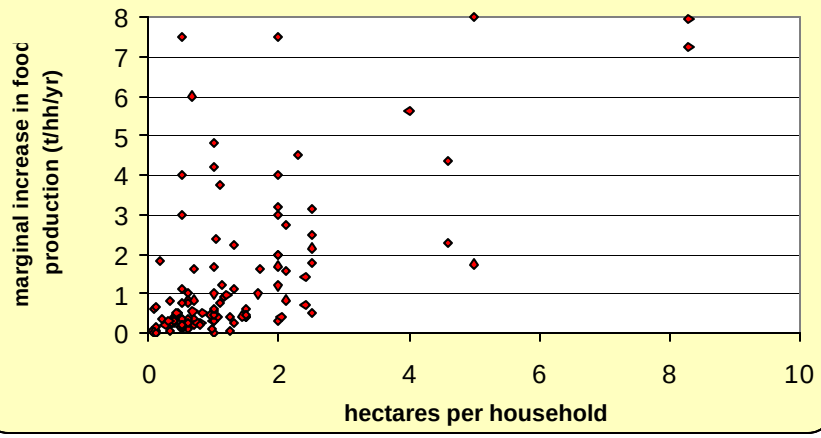
34. Most sustainable agriculture projects and initiatives report significant increases in household food production - some as yield improvements, and some as increases in cropping intensity or diversity of produce (Figure E2). The evidence shows that:

i) for the 4.42 million farmers on 3.58 million hectares, average 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. size = 90 ha/farm), total production increased by 150 tonnes per household (an increase of 46%).

Figure E2. Increase in annual household food production with sustainable agriculture (3.56 million households on 4.3 million hectares; 79 projects)



35. Few projects, 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.

36. Despite this, several projects have reported surpluses and regional improvements to food production. 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. These areas can also see productivity increase over time, as the natural and human capital assets increase.

Reasons for Success/Constraints on Spread

37. We analysed the completed questionnaires and project data to explore i) stated reasons for success in projects and initiatives; and ii) limits and constraints on the further spread of technologies, practices and approaches. 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.

38. 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.

39. 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 rural communities and between external agencies.

Impacts on Rural Livelihoods

40. The empirical evidence suggests that the nine types of sustainable agriculture improvements have a variety of positive effects on people's livelihoods. 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

41. At some locations, sustainable agriculture has had a significant impact on labour markets. 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.

42. 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.

Dietary and Reproductive Health

43. 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 many projects, for example, raised beds in kitchen gardens have improved domestic food supply by producing a year-round supply of vegetables – and children are often the main beneficiaries. In some cases, a more sustainable agriculture can also help to remove threats to health in the environment - such as consumption of mosquito larva by fish in rice fields in China.

44. 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.

Large Farms, Small Farms and Landless Families

45. In certain circumstances, sustainable agriculture practices appear to be currently more accessible to larger farmers - particularly the zero-tillage systems in southern Latin America. However, evidence from Paraguay and Brazil also suggests that many small farmers adopt and adapt elements of these practices if the process if interaction is participatory.

46. 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.

47. Sustainable agriculture can result in improvements in livelihoods for landless families and the core poor in three ways: improvements to labour markets, improved access to land through land reform, or changed social norms that encourage greater equity and sharing.

Social Learning Processes to Understand and Manipulate Megabytes in Fields

48. 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 biophysical complexity in their fields and farms, and then to act in different ways. The process of learning, if it is socially-embedded, provokes changes in behaviour and can bring forth a new world.

49. 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. 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.

50. 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.

Improvements to Soil Health

51. 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.

52. 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-releasing plants into rotations, use of composts and animal manures, adoption of zero-tillage, and use of inorganic fertilizers.

53. One 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. In Argentina, there were 9.2 million hectares under ZT in 1999 - up from less than 100,000 ha in 1990. 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.

54. 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. 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.

Pest Control with Minimal or Zero Pesticides

55. Many sustainable agriculture projects have reported very large reductions in pesticide use following the adoption of IPM through farmer field schools in rice agroecosystems. In Vietnam, farmers cut the number of sprays form 3.4 to 1 per season, and in Sri Lanka from 2.9 to 0.5 per season.

56. 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. 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. 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.

Making Better Use of Water

57. 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.

58. Water harvesting can lead to improved production in both drylands and extra crops in wetlands. Improved management of water in irrigated systems can also make a significant difference to outcomes.

Adding Value and Marketing - the Forgotten Components

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

Confounding Factors

60. 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. 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 for marketing near a forest can result in loss of natural capital, as it also aids timber extraction.

61. 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.

62. 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 market losses lightly.

63. 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.

On Policies for Sustainability

64. Several things are now clear with respect to sustainable agriculture:

i) The technologies and social processes for local level sustainable agriculture are well-tested and established;

ii) The social and institutional conditions for spread are less well-known, but have been established in several contexts, leading to very rapid spread in the 1990s;

iii) The political conditions for the emergence of supportive policies are least well established, with only a very few examples of real progress.

65. The past decade has seen considerable global recognition of the need for policies to support sustainable agriculture. In a few countries, this has been translated into