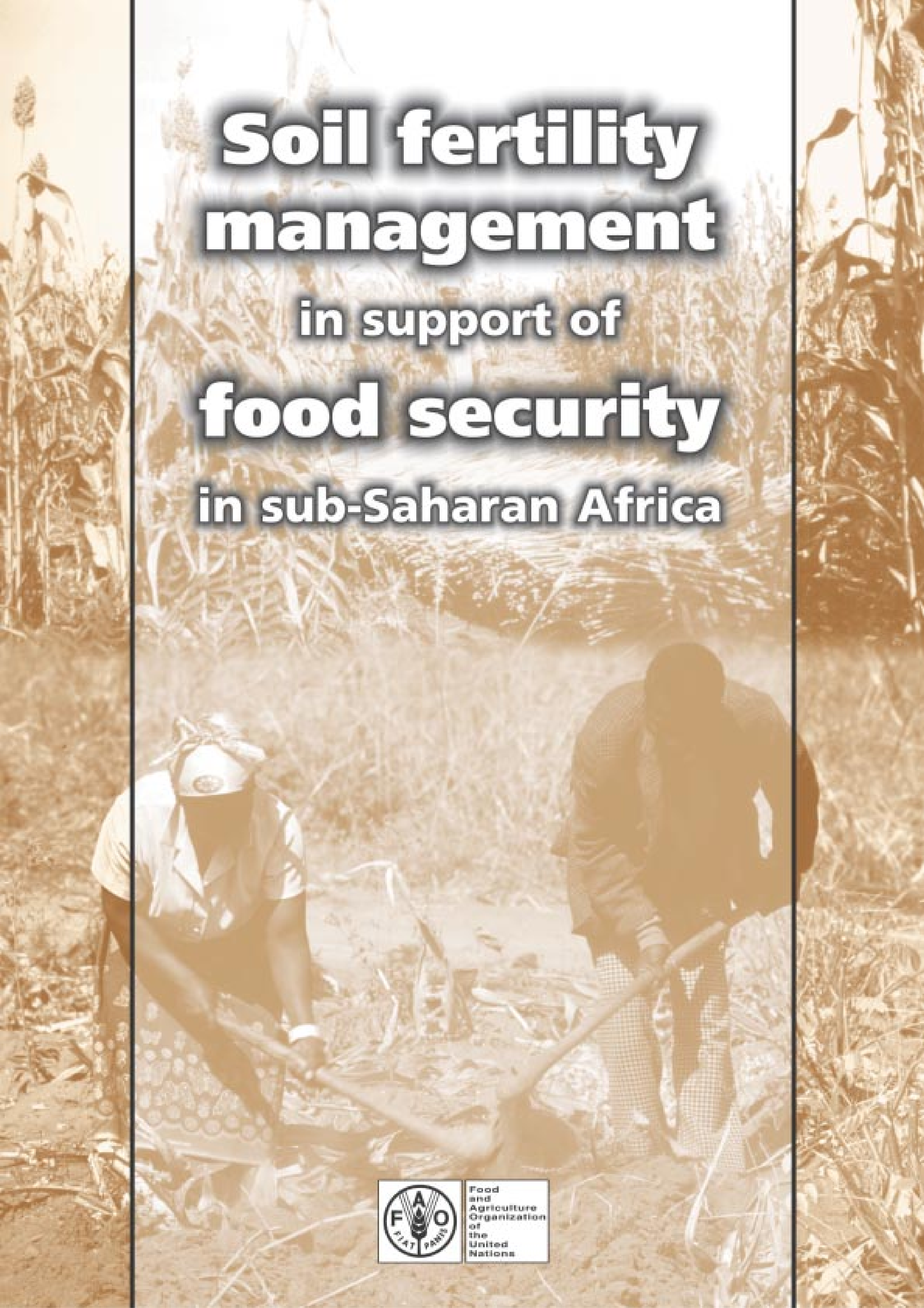
Soil fertility management in support of food security in sub-Saharan Africa



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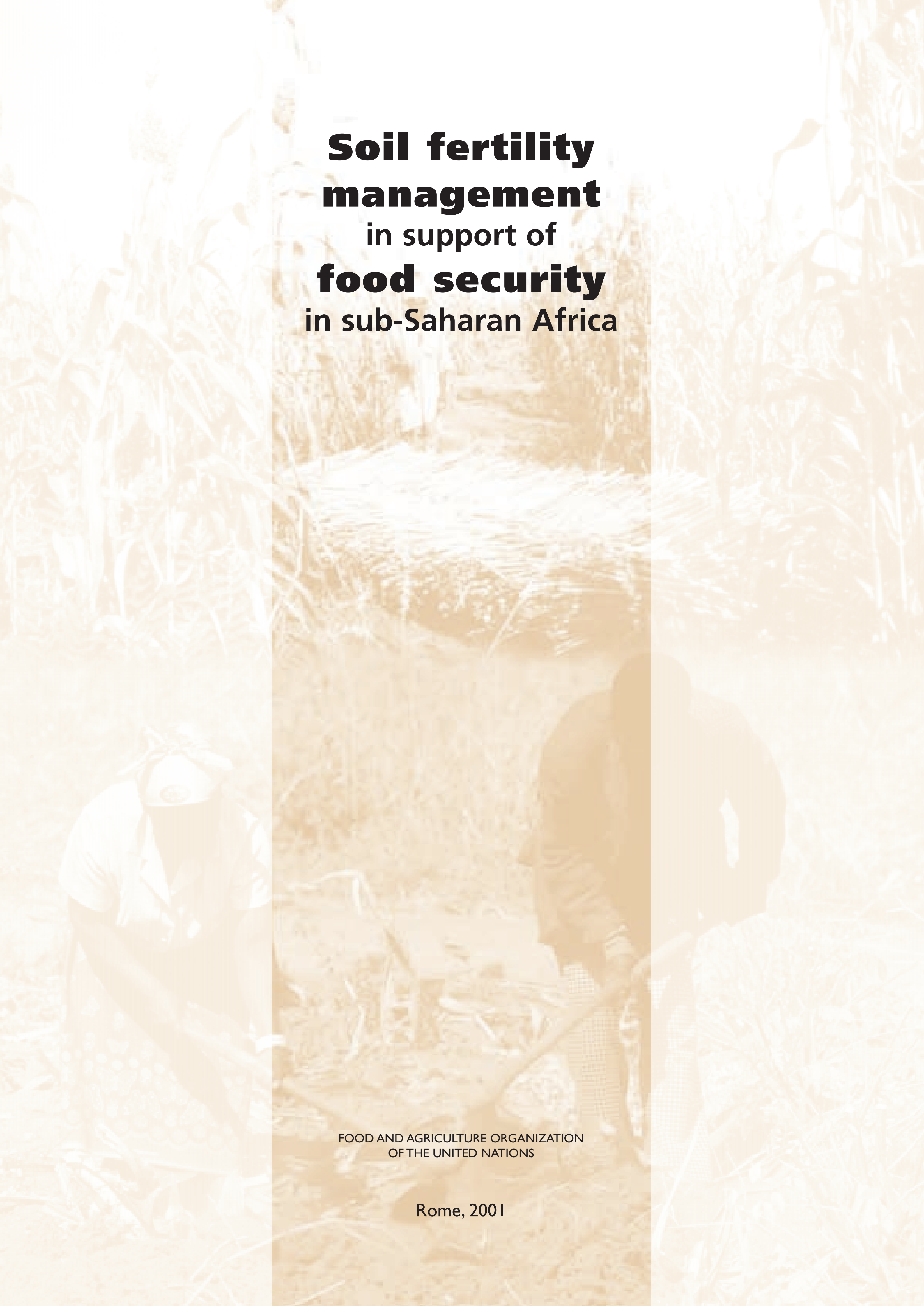

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Preface

Land degradation will remain an important global concern because of its adverse impacts on agricultural production, food security and the environment. Inappropriate land management, particularly in areas with high population densities and fragile ecosystems, further increases loss of productivity of resource - poor farmers. This in turn affects their food security and livelihood.

Large areas of sub-Saharan African soils, in particular, are affected by various types of degradation, including fertility decline. Soils in most SSA countries have inherent low fertility and do not receive adequate nutrient replenishment. Consequently, yields are relatively low despite the high potential for improvement.

As the main source of economic activity in SSA is the agricultural production, declining soil productivity means not only less food is grown but also that production of cash crops and income are endangered. Thus, rectifying land degradation and enhancing productivity through appropriate soil management and conservation can play a major role in achieving farm household food security and agricultural development.

This publication reviews issues related to land degradation, with focus on problems of soil fertility management in SSA. It highlights some successful experiences in the region, constraints and possible solutions specific to the major agro-ecological zones and the importance of holistic and participatory approaches for soil productivity improvement. The need for action and collaborative efforts of all stakeholders, within the framework of ongoing initiatives are emphasized.

It is hoped that this document will contribute to increasing awareness of senior specialists and policy-makers about the problems and alternative solutions towards enhanced and sustained soil productivity.

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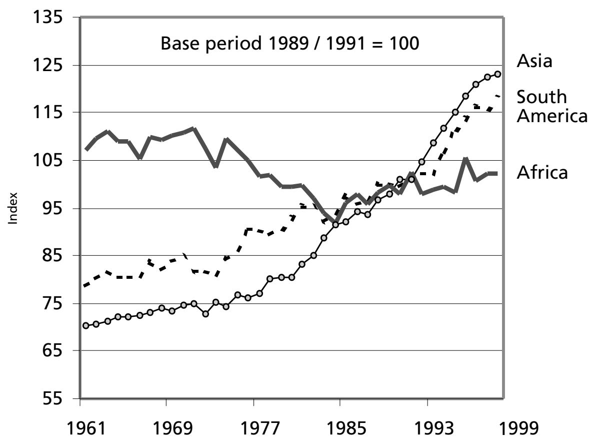
Acronyms

AGL	Land and Water Development Division (FAO)
AGLL	Land and Plant Nutrition Management Service (FAO)
ASIP	Agriculture Sector Investment Programme
CSD	Commission on Sustainable Development
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
GIS	Geographic Information Systems
GLASOD	Global Assessment of Human-induced Soil Degradation
IBSRAM	International Board for Soil Research and Management
ICRAF	International Centre for Research in Agroforestry
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Centre
IPNS	Integrated Plant Nutrition Systems
ISRIC	International Soil Reference and Information Centre
ISSS	International Society of Soil Science (now IUSS)
IUSS	International Union of Soil Science
NAP	National Action Programme
NGO	Non-governmental Organization
SDRN	Environment and Natural Resources Service (FAO)
SFI	Soil Fertility Initiative
SOTER	Soil and Terrain Digital Database
SPFS	Special Programme for Food Security
SSA	Sub-Saharan Africa
SWC	Soil and Water Conservation
TCI	Investment Centre Division (FAO)
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WB	World Bank
WOCAT	World Overview of Conservation Approaches and Technologies

Introduction

Agricultural growth in sub-Saharan African countries slightly increased over the past three decades, although not in line with the high population growth rate. Food production per capita in sub-Saharan Africa (SSA) has declined since the 1970s, in contrast with the increase in Asia and South America (**Figure 1**).

Figure 1 Regional trends in food production per capita



Source: FAO, Statistical Analysis Service, 2000

Soils in most SSA countries have inherent low fertility and do not receive adequate nutrient replenishment. Soil productivity in SSA is also constrained by aridity (low rainfall) and acidity. Although little production increase has taken place, this has been obtained by cultivation of poor and marginal lands while the productivity of most existing lands has been declining.

With population continuing to increase in all parts of Africa, the need to reverse these declining trends has become more urgent. Improving soil fertility could trigger rural and national economic development, achieve long-term food security and improve farmers' standards of living, while mitigating environmental degradation and rural migration. However, soil fertility and productivity enhancement have to be supported by policies with regard to credit facilities, produce and input prices, access to markets and secure land tenure.

Agricultural production and food security

Agriculture in SSA needs to grow by four percent per year to meet the food requirements of the growing population. The conservation, recapitalization and maintenance of soil fertility are prerequisites to improved efficiency of inputs and higher productivity.

The major problems of soil fertility management in SSA are:

- **Population growth:** population has to date increased faster than the increase in production.
- **Pressure on land:** cultivated areas are increasing (mostly on marginal lands) to compensate for the low yields from existing cultivated land.

- **Food production:** yields in many areas remain low and most farmers cannot purchase inputs.
- **Land degradation and soil fertility decline:** soils are exploited without restoration of soil fertility.
- **Droughts:** climate patterns are changing, leading to an increased incidence of droughts and floods in some areas.
- **Land rights:** insecurity of tenure is a major impediment to land management and conservation, and hence to food security.
- **Technology:** there is a lack of well-adapted technologies and irrigation is not yet a viable option in many places; there is also a lack of economic incentives for farmers to adopt soil fertility management technologies.

This document was prepared on the basis of many FAO documents and Expert Consultation proceedings (Zimbabwe, 1997 and 1998). For further information, please refer to the Bibliography.

Food security in sub-Saharan Africa: main issues and problems

Population density in some countries of SSA is still lower than in Asia. The rate of population growth, however, is far faster in SSA than in any other region of the world. Thus, in many countries and regions of SSA there is more pressure to make the transition from low-input traditional systems to more productive systems. Soils and climates also impose great constraints on intensification.

Production has to be increased, but the methods must be economically viable and socially acceptable. Among the major problems is soil fertility management, which is linked with the availability of arable land, the use of mineral fertilizers, the restoration of soil fertility (recycling manure and crop residues, fallow practices, use of legumes, etc.), water management and climate fluctuations (droughts, etc.).

The alternative route to food security is to ensure that the economic means to purchase food exist, and that the food can be purchased at affordable prices.

One important prerequisite is access to land, as more people need to produce their food supplies and make a living from the land. Traditional land management systems are dependent on the availability of sufficient land to allow long fallow periods to maintain soil fertility. When there is no more access to new land, the fallow land has to be used and soil fertility falls.

More intensive use of the land also implies that it becomes more prone to soil erosion. To maintain and raise its productivity, new sustainable management measures have to be introduced and policies changed.

Soil fertility management – a main issue for food security and agricultural development in SSA

As the main source of economic activity in SSA is agricultural production, declining soil productivity means not only that less food can be grown but also that production of cash crops for export is endangered. It is therefore essential that production and soils be managed in a sustainable way, so that the present generation is fed and soil conditions are improved to support future generations.

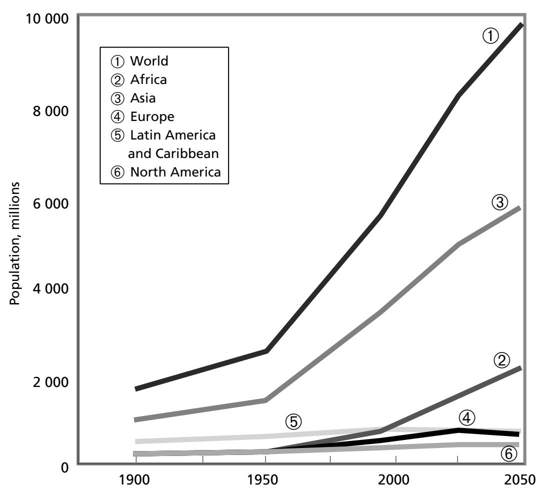
Demographic pressures and changes

Population growth

There is little immediate prospect of a significant decline in the rate of population growth in Africa. This is not only due to the population momentum (high proportion of the population which is of childbearing age) and the increasing life expectancy, but also the lack of efforts to reduce birth rates. In SSA population is seen as an important resource for development and income.

On this basis, it is expected that population in SSA will at least double within the next 25 years (**Figure 2**).

Figure 2 Estimated population growth in various regions



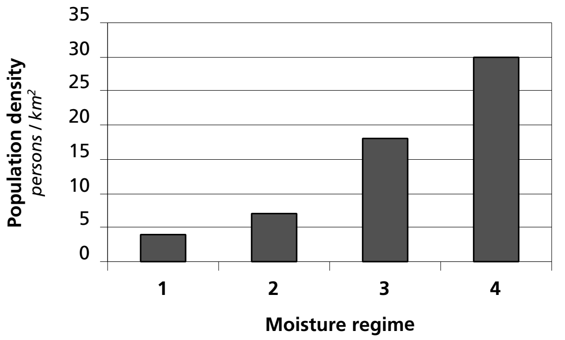
Source: UN, 1997

By international standards the population density in SSA is low, but the major problem is the capacity of the land to support such population growth and the lack of opportunities for employment of the people in productive industry outside agriculture.

The problems of population growth have been aggravated in some areas by migration of large numbers of people, due to pressure on land, but also to political factors, leading to, or caused by civil strife.

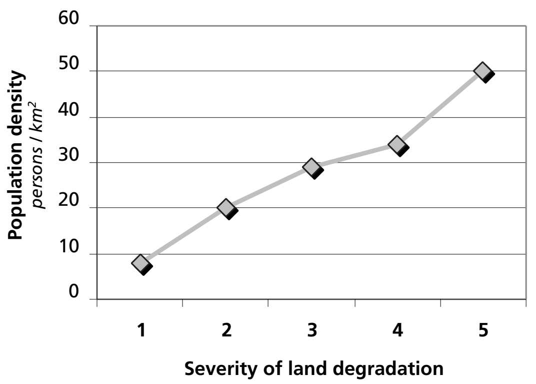
Analyses by FAO in 1999 show that population density is related to water availability (**Figure 3**) and that land degradation is more severe at high population density in SSA (**Figure 4**).

Figure 3 Population density in arid and semi-arid regions in SSA



Moisture regime: 1 = Very arid; 2 = Arid; 3 = Dry semi-arid; 4 = Semi-arid

Figure 4 Severity of land degradation and population density in SSA



Severity of land degradation: 1 = none; 2 = light; 3 = moderate; 4 = severe; 5 = very severe

National reports presented at the FAO Expert Consultation in Harare (December 1997) dealt with the issue of reconciling population growth and food production. Some of the country comments include:

- **Zimbabwe:** future prospects are grim in view of the population growth rate.
- **Malawi:** the country is facing serious problems of food security, declining land holdings, accelerating deforestation and degradation of the natural resource base.
- **Ethiopia:** land degradation poses the greatest long-term threat to human survival in the country and remains one of the greatest challenges facing the ever-growing population and the Government.
- **South Africa:** the country has to face high population growth, poverty, accelerated soil degradation and increasing pressure on land.
- **Uganda:** population is growing faster than food production and the situation is alarming.

Pressure on land

The most recent assessment of the available land in Africa indicates that there is between 0.28-0.52 ha per person of cultivated land. This includes a high proportion of land in low-rainfall areas, or with other serious constraints (**Table 1**). But if it is assumed that all the people are concentrated in the areas with good rainfall, the cultivated areas are only between 0.19 and 0.23 ha per person. These figures are in fact close to those reported in the country papers: e.g. in Ethiopia in 1991 it was 0.28 ha per person, and in Uganda in 1995 it was 0.25 ha.

It is assumed that some land is continuously cultivated, some is cropped more than once per year, and more than half is under fallow each year.

Table 1 Population, cultivated and available land in different agro-ecological zones of SSA

Region	Population(1) 1995	Population(1) 2025*	Land(2)	Rainfall areas(3) –	Rainfall areas(3) ?	Rainfall areas(3) +	LUR(4)	Gleys	Total	Total ha/ person 1995
East	221	480	C	8.4	15.3	25.8	10.7	2.6	62.8	0.28
			A	7.4	10.9	20.1	10.6	8.1	57.1	
South	47	83	C	2.6	6.0	4.2	2.9	2.0	17.7	0.38
			A	7.1	5.1	2.8	5.9	0.7	21.6	
Centre	83	187	C	1.4	5.7	13.2	21.9	0.9	43.1	0.52
			A	4.9	16.9	32.0	28.2	4.7	86.7	
West	209	447	C	20.8	19.8	20.0	25.2	4.5	90.3	0.43
			A	8.5	18.5	26.9	10.0	3.5	67.4	
TOTAL	**560**	**1197**	**C**	**33.2**	**46.8**	**63.2**	**60.7**	**10.0**	**213.9**	**0.38**
			A	**27.9**	**51.3**	**81.7**	**54.7**	**17.0**	**232.6**	
			C+A	**61.1**	**98.1**	**144.9**	**115.4**	**27.0**	**446.5**	

Source: Fischer and Heilig, 1997

(1)Population in millions; (2)Land in million hectares: C is cultivated area, A is available land, omitting land for habitat, protected land and forested land and wetlands; (3)Rainfall areas: '-' = Low; '?'= Uncertain; '+' = Good; (4)LUR: areas with serious land use restrictions, and gleys refer to potentially usable Gleysols and Fluvisols; *UN medium variant

East: Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Reunion, Rwanda, Somalia, Uganda, Tanzania, Zambia and Zimbabwe.

South: Botswana, Lesotho, Namibia, South Africa and Swaziland.

Centre: Angola, Cameroon, Central African Republic, Chad, Congo, Equatorial Guinea, Gabon, and the Republic of Congo (formerly Zaire).

West: Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo.

The figure of 233 million ha of land available for cultivation is probably the best estimate, at present, of the land in sub-Saharan Africa that may still be brought into cultivation before 2025. However, the productivity of the new land can hardly be as high as that of the currently cultivated land, as much of it is marginal. Available land area must be considered in relation to the potential of that land for crop production, and its distribution in relation to demand in different countries.

Food production

Africa's average cereal yield during the period 1991 to 1998 was stagnant, at about 1.2 tonnes/ha. By 2020, even assuming optimistically that national average cereal yields increase to 1.8 tonnes/ha, Africa will need to import between 25 and 32 percent of its cereal demand to remain at present nutritional levels. To attain this level of food supply, major efforts have to be made to change to more productive and biophysically sustainable production systems, and the present social, economic and political constraints will need to be removed.

Increasing food production

Food production can be increased through:
- Increasing land under cultivation, though this means the use of more marginal lands and the loss of important environmental services from forests.
- Recycling manure, use of crop residues, use of green manures and cover crops; and adoption of agroforestry.
- Use of mineral fertilizers, though these are often too expensive for poor farmers.
- Changing the farming systems to become more productive and sustainable.
- Increasing investments for land improvement and promoting a conducive land tenure system.
- Efficient water use.

Policies will be needed not only to produce higher yields but also to encourage the movement of people to high potential areas where land is available. Such policies require careful management as the experience with transmigration in Indonesia has shown. But if this is to be done successfully, and at least intermediate levels of inputs used, there should be sufficient land not only to meet a specific country's needs, but also to provide production in excess for export to other countries.

Land degradation

Understanding the types of human-induced land degradation as well as their causes, including the related socio-economic factors, is a prime requirement for developing mitigation technologies.

In general, the three major categories of land degradation are:

- **Physical degradation**, including water and wind erosion, crusting and sealing, compaction, waterlogging and reduced infiltration.
- **Chemical degradation**, including acidification, nutrient depletion, pollution from industrial waste and excessive or inappropriate application of pesticides or fertilizers.
- **Biological degradation**, including soil organic matter decline, biomass burning and depletion of vegetation cover and soil fauna.

Assessment of land degradation

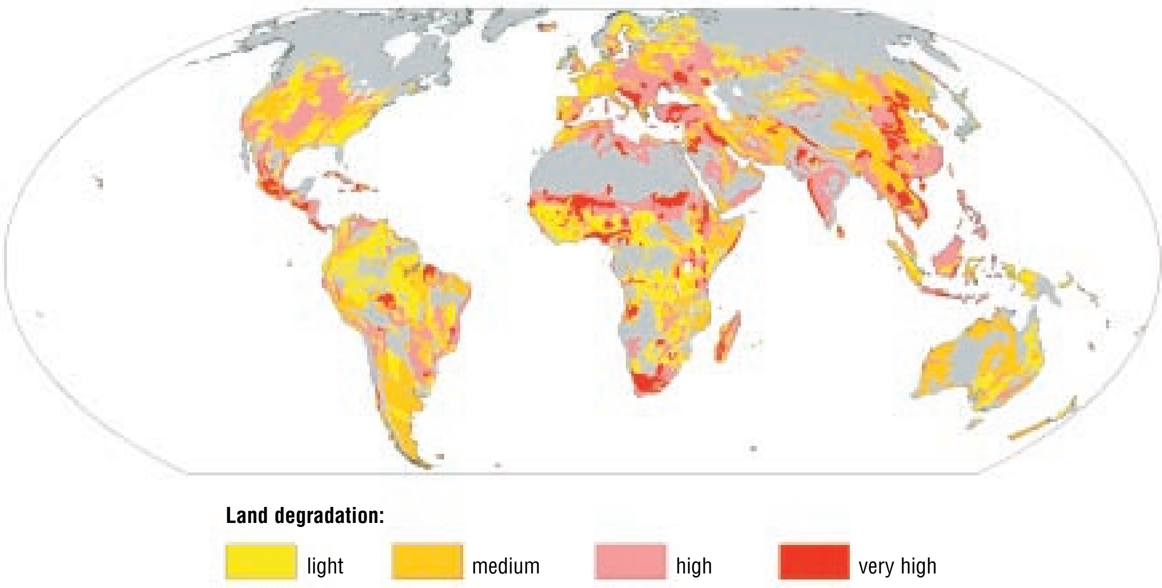
The "Global Assessment of Human-induced Soil Degradation" project (GLASOD – ISRIC/UNEP/FAO 1990) assessed land degradation at global level (**Table 2**) and produced a map at a scale of 1:15 million (summarized in **Figure 5**).

Table 2 Soil degradation in the world and in Africa – million ha (GLASOD)

World		Africa	
Africa	494	Water erosion	227
Asia	748	Wind erosion	187
South America	243	Chemical degradation	62
North & Central America	158	Physical degradation	18
Europe	219		
Australia	103		
World	**1964**	**Total**	**494**

Source: ISRIC, 1990

Figure 5 World map of severity of land degradation (GLASOD)



Source: ISRIC / UNEP, 1990

The direct causes of land degradation are mainly:

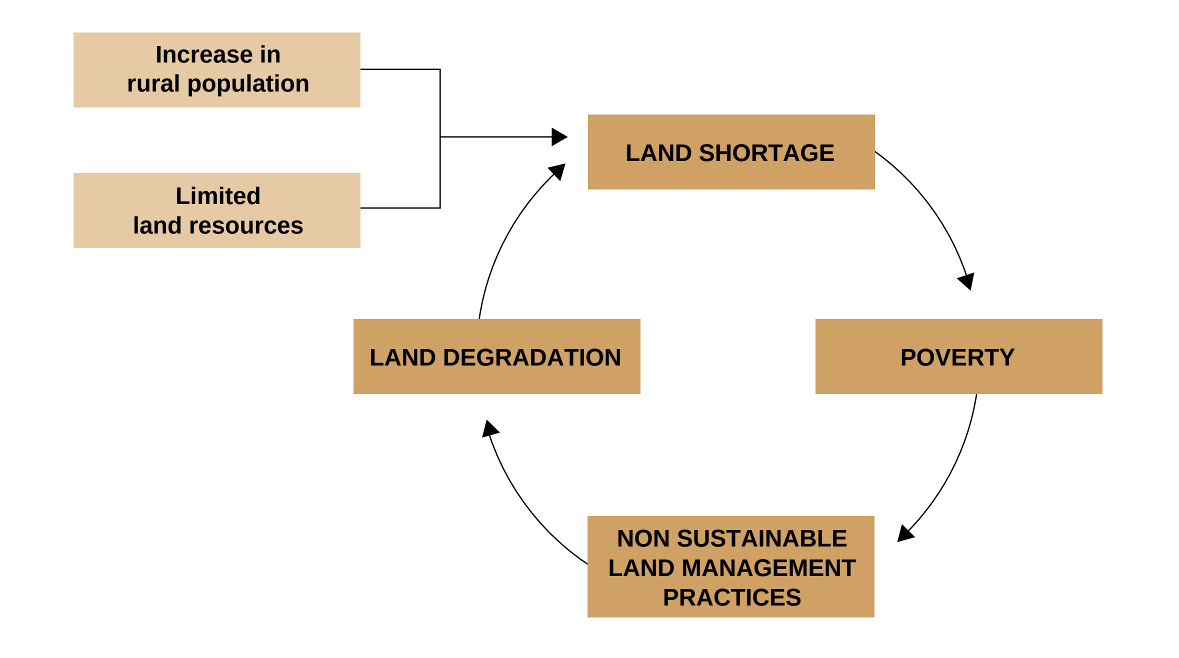
- Deforestation.
- Overgrazing and over-cutting.
- Shifting cultivation.
- Agricultural mismanagement of soil and water resources: such as non-adoption of soil and water conservation practices, improper crop rotation, use of marginal land, insufficient and/or excessive use of fertilizers, mis-management of irrigation schemes and overpumping of groundwater.

The indirect causes of land degradation are mainly:

- Population increase.
- Land shortage.
- Short-term or insecure land tenure.
- Poverty and economic pressure.

All the causes mentioned above, especially indirect causes, are associated with each other (**Figure 6**).

Figure 6 Causal nexus among land resources, population, poverty and land degradation



Soil fertility decline

Soils in most of SSA have inherently low fertility and do not receive adequate nutrient replenishment. SSA has the lowest mineral fertilizer consumption, about 10 kg nutrients (N, P_2O_5, K_2O)/ha per year, compared to the world average of 90 kg, 60 kg in the Near East and 130 kg/ha per year in Asia.

Soil fertility decline (also described as soil productivity decline) is a deterioration of chemical, physical and biological soil properties. The main contributing processes, besides soil erosion, are:

- Decline in organic matter and soil biological activity.
- Degradation of soil structure and loss of other soil physical qualities.
- Reduction in availability of major nutrients (N, P, K) and micro-nutrients.
- Increase in toxicity, due to acidification or pollution.

For a first assessment of the state of nutrient depletion in 1990, nutrient balances were calculated for the arable lands of 38 countries in SSA. Four classes of nutrient-loss rates were established (**Table 3**).

Table 3 Classes of nutrient loss rate for SSA (kg/ha per year)

Class	N	P_2O_5	K_2O
Low	< 10	< 4	< 10
Moderate	10 – 20	4 – 7	10 – 20
High	21 – 40	8 – 15	21 – 40
Very high	> 40	> 15	> 40

Source: Stoorvogel and Smaling, 1990

The average nutrient loss was estimated to be 24 kg nutrients/ha per year (10 kg N; 4 kg P_2O_5, 10 kg K_2O) in 1990 and 48 kg nutrients/ha per year in 2000, i.e. a loss equivalent to 100 kg fertilizers/ha per year. Countries with the highest depletion rates (**Table 4**), such as Kenya and Ethiopia, also have severe soil erosion.

Table 4 SSA countries classified by nutrient depletion rate

Low	Moderate	High	Very high
Angola	Benin	Côte d'Ivoire	Burundi
Botswana	Burkina Faso	Ghana	Ethiopia
Central Africa Rep.	Cameroon	Madagascar	Kenya
Chad	Gabon	Mozambique	Lesotho
Congo	Gambia	Nigeria	Malawi
Guinea	Liberia	Somalia	Rwanda
Mali	Niger	Swaziland	
Mauritania	Senegal	Tanzania	
Mauritius	Sierra Leone	Uganda	
Zambia	Sudan	Zimbabwe	
	Togo		
	Zaire		

Source: Stoorvogel and Smaling, 1990

The estimate of nutrient depletion in SSA is widely quoted. Some scientists, however, have expressed concern about the approach used, as it is based on approximation and aggregation at country level - which could be misleading, masking the "bright" spots and the "hot" spots where urgent nutrient replenishment is required. Assessment of fertility decline at microwatershed or community level would be more appropriate, but would be costly and time-consuming.

Improved crop varieties and the use of fertilizers (and pesticides) have given rise to yield increases for the past three decades in many humid regions of the world, but there have been no substantial corresponding increases in SSA. Soils in SSA have been farmed more intensively without restoration of fertility (due to limited use of fertilizers and other soil management practices), and much of the new land brought into production has been of lower quality than the existing cultivated land.

Stagnant or declining yields of major food crops, particularly of cassava, are still occurring in many countries in Africa, in spite of the considerable efforts that have been made to increase productivity (**Table 5**). Changes in crop yields measured over several decades reflect changes in soil conditions, as well as the effects of other factors.

Table 5 Evolution of national average yields of major food crops in SSA (1975, 1986 and 1994)

COUNTRY	MAIZE, kg/ha			SORGHUM, kg/ha			CASSAVA, kg/ha		
	1975	1986	1994	1975	1986	1994	1975	1986	1994
Angola	722	461	340				14.1	10.1	4.1
Burundi	**1095**	**1200**	**1312**	*1269*	*1203*	*1117*	14.1	11.1	8.7
Ethiopia	**1466**	**1764**	**1715**	**994**	**1101**	**1299**			
Kenya	**1619**	**1433**	**1896**	*1064*	*792*	*1041*	*8.1*	*9.8*	*8.7*
Malawi	**1087**	**1090**	**1266**	847	1111	471	5.8	5.7	2.7
Namibia	**329**	**480**	**1028**	**391**	**480**	**655**			
Nigeria	**835**	**2098**	**1259**	**620**	**1094**	**1065**	*10.0*	*11.1*	*9.5*
Rwanda	**1058**	**1323**	**1482**	*1037*	*1014*	*1077*	12.3	9.7	5.7
Tanzania	**813**	**1196**	**1376**	**503**	**828**	**1020**	**4.9**	**12.2**	**10.4**
Uganda	**1225**	**1153**	**1599**	**1127**	**1249**	**1501**	**3.8**	**9.6**	**7.5**
Zambia	**792**	**1921**	**1815**	*649*	*604*	*507*	**3.1**	**3.5**	**5.1**
Zimbabwe	1613	1666	1294	**336**	**604**	**507**	*3.0*	*4.2*	*3.9*

Increasing yields *Stagnant yields* Decreasing yields

Adapted from FAO Production Yearbooks

Overgrazing

Animals are a major part of the food production system in the arid, semi-arid and subhumid regions. The value of animal manure in crop production has long been widely recognized, and is essential for sustainable crop production in most low and intermediate input systems. Animal manure is also essential as part of integrated nutrient management systems even when high levels of inputs are used. Cattle are also important as draught animals and as a mark of status and wealth in many parts of SSA.

Population growth often entails an increase in livestock numbers. All grasslands have a limit to the number of cattle they can support, due to the amount of vegetation produced and the availability of water supplies. If cattle population increases without restriction, the pressure on grazing areas leads to a loss of edible vegetation and dominance of shrub species, and further to desertification.

As the area of cultivated land increases, the best soils are chosen for cropping, so the productivity of the remaining pastures declines. Around watering places, the plant cover may be destroyed and soils compacted by trampling so the amount of runoff water increases. This may help to keep water reservoirs full, but as little water may enter the soil around the watering places, flash flooding may occur, leading to serious erosion.

Integrated crop production management

Sustainable land management requires not only sustainable systems for crop production but also sustainable animal production, preferably integrated with the crop production system.

In most subhumid and semi-arid areas, much of the grazing land is burnt annually during the dry season to remove the old and coarse vegetation and encourage the growth of young and more nutritious grasses. Burning causes the loss of soil organic matter and thus impairs the sustainability of agricultural production. Furthermore, it exposes the soil to the erosive forces of the wind during the dry season and of the rain at the end of the dry season. The damaging effects on the soil can be minimized by ensuring that the burn is conducted early in the dry season, but this can be only a partial remedy.

Deforestation and desertification

When land is cleared for cultivation in the humid and subhumid zones, trees have to be cut back to stumps, or totally removed. Shifting cultivators operating in areas for many years (or centuries) become ecologically aware of the factors that determine whether a cultivation system provides a sustainable source of livelihood. In traditional systems, trees are only cut back, so that within a short time are actively growing again. Provided that cultivation is not continued beyond two years the natural vegetation redevelops rapidly, the soil is protected, nutrient cycling starts again and aggressive weeds do not establish. Within five years of a short cultivation period, a closed forest canopy is formed again.

When alternative land is not available for cultivation, the cropping period has to be extended. This encourages weeds to establish, trees are gradually destroyed, and when land is abandoned, regeneration of the natural vegetation takes much longer. The destruction of the forest for agricultural production is a major cause of deforestation.

1. Land clearance by fire for crop production, Guinea.

When the shifting cultivators have no title to the land on which they settle, there is little incentive for them to improve the future productivity of that land. Then shifting cultivation may degenerate into “slash and burn”, with serious damage to the resource.

Land pressure sometimes forces people to seek more land in forest areas not previously used for agriculture. People are sometimes forced to work in new areas (displaced people or refugees) and then are more concerned with producing enough to eat than in ensuring that their methods are sustainable.

Much “pioneer farming” is also conducted, not by the poor but by those with an economic advantage, seeking control of land so that it may later be rented or otherwise exploited. However if land is rigorously cleared for mechanized cultivation, the forest will take many years to regenerate. The most destructive clearing is usually highly mechanized. Those who have only hand tools are mostly more conserving in their clearance methods.

The regrowth of vegetation after clearing for cultivation is much slower in semi-arid regions. Grassy weeds are rapidly established, and recycling of nutrients may be negligible. Usually, a larger area must be cultivated than in the humid zone to maintain subsistence for the family and there is a greater advantage of plough cultivation than in the forest areas. Plough cultivation requires that most tree stumps are removed, and so the re-establishment of a vegetative cover is a significantly slower process.

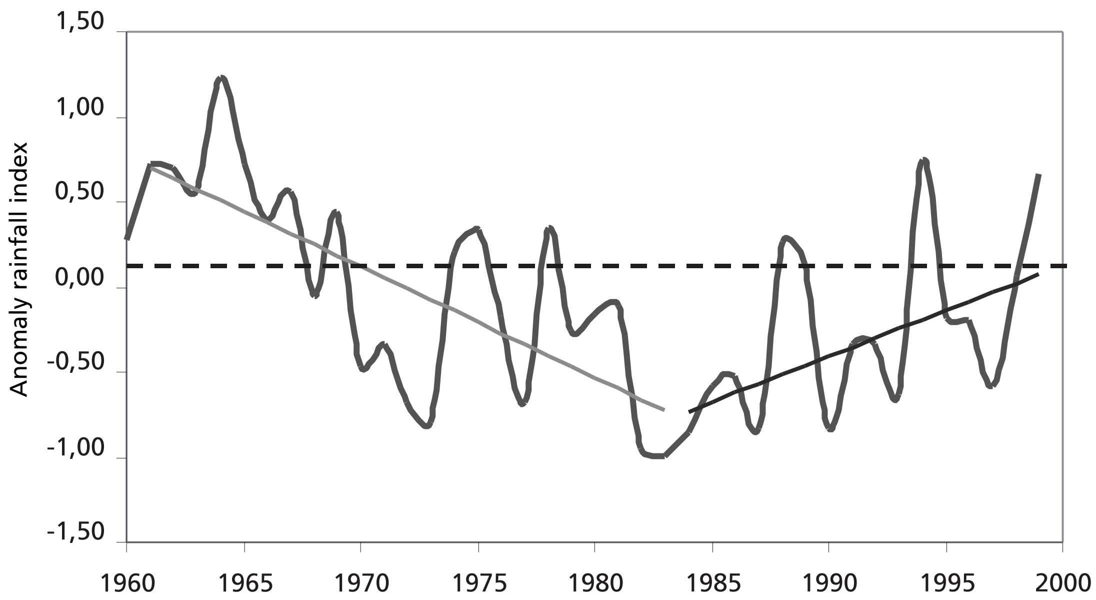
Furthermore, the annual burn of the vegetation severely reduces the return of organic matter to the soil; thus losing its benefits (fertility, better structure, water retention, biodiversity, etc.); and the land becomes poorer.

In the drier areas, destruction of trees and other vegetation is an important part of land degradation, widely referred to as desertification.

2. Destruction of vegetation due to drought in Senegal.

The GLASOD findings show clearly that there is significant soil degradation in these regions. In the Sahel there was a continual rainfall decline from over the 20 years up to 1984, and a trend of slightly increasing rainfall from 1984 (**Figure 7**). However, these trends of the overall average rainfall in the Sahel should be seen in relation to the considerable inter-annual fluctuations.

Figure 7 Rainfall anomaly indices and trends for the Sahel (1960-1999)



Source: Agrometeorology Group, SDRN, FAO.

Deforestation and desertification: causes or symptoms

Deforestation and desertification are both causes and symptoms of the deteriorating productivity as the problems are cyclical: intensive land use - induced by the need to produce more - causes soil degradation and lower yields, which demand that more land is cleared for cultivation. Government policies should recognize the effects of both, so that measures can be implemented that change this vicious cycle into a "virtuous cycle" of restoration and improvement.

Land rights and entitlements

Traditional land rights in many countries in SSA derive from communal arrangements. The strength and manner in which these are enforced differ widely, but in many traditional systems the right to cultivate land that has previously been used by the same family is strongly upheld. As land pressure grows, disputes over the right to land become common and without new land available, the existing land is being fragmented. Application of the traditional land rights system becomes more and more difficult and pressures develop to ensure formal ownership of existing cultivated land.

Grazing land is also widely regarded as communal property, and access is normally restricted to members of a particular community. Again, as the size of the community has grown, the number of livestock using the grazing land has increased, giving rise to land degradation. Pressure to reduce livestock numbers has usually been resisted because of the social and economic roles of animal ownership.

Communal wooded areas have also been degraded as the extraction of firewood and poles for building has intensified. Individual title to use areas within non-arable land would be difficult to establish, but firm recognition of communal rights will be required to encourage the development of user associations to cooperate in the proper management of such areas.

The changes in management practices to improve productivity involve various inputs and the question of who will benefit from those improvements immediately arises as the benefits may occur only several years after. If the land users do not have the security of tenure for their families and heirs they will be reluctant to make the investments, even with government support.

The country papers presented at the Harare Expert Consultation also recognize the importance of land tenure problems in relation to sustainable agriculture:

- **Zimbabwe:** land tenure and distribution have been the most important causes of soil mismanagement.
- **Zambia:** the lack of full compensation for the land on termination of a lease creates insecurity for the leaseholder; such unregulated, self-interested use of land results in degradation.
- **Ethiopia:** with the lack of land ownership, farmers have the tendency to make the land less attractive to others.
- **United Republic of Tanzania:** evaluation of land tenure aspects is essential in order to empower communities to manage their resources.
- **South Africa:** implementation of the land tenure system is a desperate requirement for a modern agricultural approach and to halt serious land degradation.

Permanent land title encourages investment in land, but does not necessarily solve all the problems of agriculture. Many African countries consider these as important reasons against land title:

- Wherever permanent titles to land exist, a land market emerges and social inequalities in income distribution tend to be exaggerated.
- Poor households are often forced to sell land and then join the unemployed in the major cities.
- Further aggravation of the problems occurs where land alienation for settler communities has taken place, as in countries of eastern, central and southern Africa.
- Land titling also requires accurate and detailed land survey, and the maintenance of records of land sales, and hence is costly to introduce.

Costs and policies

Increasing crop production in sustainable ways, introducing erosion control measures or improving the long-term productivity of the land (drainage and reclamation works, liming, etc.) involve direct costs (such as lime, gypsum or fertilizers) or indirect costs, such as that of family labour or the value foregone when land is used for erosion control strips, for example. Then, the social structure of individual households can be a major issue (extra family labour, responsibility for allocating funds, gender issues).

Such arrangements may also be hardly sustainable for small farmers if there are few short-term benefits as the crop response occurs over many years. Therefore, the constraints exerted on families may be considerable, in particular for those living at little above the subsistence level. Farmers will not pay for inputs unless they are reasonably sure that their produce can be sold at a profit. Nor will they accept conservation measures unless the long-term advantages will accrue to them, and not to others who may be occupying the land, or reaping the advantages (through taxation, for example).

Unless all these constraints are clearly recognized, any intervention to improve the livelihood of small farmers is doomed to failure. It may be necessary that the state accept part or most of the costs; this is particularly important where tenure is not secure. Subsidies for drainage and liming were provided in many developed countries for many years, and fertilizer use has been subsidized in several countries in Africa. Irrigation schemes to increase land productivity have generally been funded by the state, and water charges are the exception rather than the rule.

Thus government policies related to these economic and social factors can have a determining influence on whether practices to increase production are sustainable or not. Policies related to land tenure may be the most important, but governments can also exert a strong influence on the use of inputs and conservation measures by appropriate pricing and subsidy policies.

Policies relating to how government funds are allocated (agricultural and industrial development, roads and water supplies, defence and food security) can also impose severe constraints on the improvement of agricultural production. Accepting food aid or importing food at low prices can become a major obstacle to local production. The stability of long-term production is threatened if the producers believe that whenever they have food to sell, it will be forced out of the market by cheap imports.

Managing soil fertility in different agro-ecological zones

The great majority of farms in SSA are small, seldom exceeding five ha and often less than one ha. Many of these farms are dependent on natural fallow to maintain soil fertility. When a cash crop is grown (cotton, tobacco, etc.), the fields may receive mineral fertilizers, but this is rare for food crops. The fallow land is grazed and the manure may be collected for application to the home garden.

The major agro-ecological characteristics in SSA are summarized in **Table 6**. A small-scale map of the six main agro-ecological zones in SSA is given in **Figure 8**. More detailed agro-ecological maps are useful and make technology transfer more effective.

There is a natural reluctance among farmers to change their farming systems that have been well adapted for generations. However, as circumstances have changed (population increase, land degradation, etc.) the farming systems have to change. Farmers need all the support that science and cooperation can provide, but it must be carefully integrated into the farmers' environment. For instance, the FAO guidelines on agro-ecological zoning can be used to decide the biophysical attributes to be considered in optimizing farming systems. But the recommendations based on these attributes have to be adapted to the socio-economic conditions of the farmers. Therefore, farmers must be actively involved not only in the assessment of research and related recommendations but also at the design stage of land productivity improvement programmes.

Table 6 Characteristics of major agro-ecological zones in SSA

	Population projected (million) 2000	2010	2025	Main climate characteristic LGP*	Rainfall**	Major soil types	Dominant vegetation	Current farming systems
Humid and subhumid regions								
West Africa	215.9	283.9		>180	>1000	Ferralsols and Luvisols	Tropical moist forest and forest-savannah mosaic	Shifting cultivation and semi-permanent cultivation with low inputs. Perennial tree crops with root crops.
Central Africa	64.8	83.2		>270	>1500	Ferralsols and Acrisols		Shifting cultivation, perennial tree crops with root crops.
Subhumid mountainous region								
East Africa	149		281	180-270	900-1500	Nitisols, Ferralsols, Andosols	Montane forest and grassland	Semi-permanent and permanent cultivation with mixed crops and animals.
Subhumid and semi-arid southern Africa								
Subhumid	99		199	120-270	700-1500	Ferralsols, Luvisols, Cambisols	Dry forest-savannah mosaic, with grasslands	Shifting cultivation, semi-permanent mixed farming.
Dry Semi-arid	20		41	75-120	250-700	Luvisols and Arenosols	Dry forest-savannah mosaic	Shifting cultivation, semi-permanent mixed farming, pastoralism.
Sudano-Sahelian Africa								
Dry Semi-arid				75-120	250-700	Arenosols	Thorny shrubs with annual grasses	Nomadism with supplementary mixed farming, pastoralism.
	102.7***		127.8***					
Moist Semi-arid				120-180	700-1300	Luvisols and Arenosols	Deciduous tree savannah with perennial grasses	Partial nomadism, shifting cultivation and semi-permanent mixed farming.

Source: FAO, 1986 – African agriculture: the next 25 years (adapted)

*LGP: length of growing period, in days per year; **in millimetres per year;
***Not divided between moist and dry semi-arid

West Africa: Benin, Côte d'Ivoire, Ghana, Guinea, Guinea Bissau, Liberia, Nigeria, Sierra Leone, Togo.

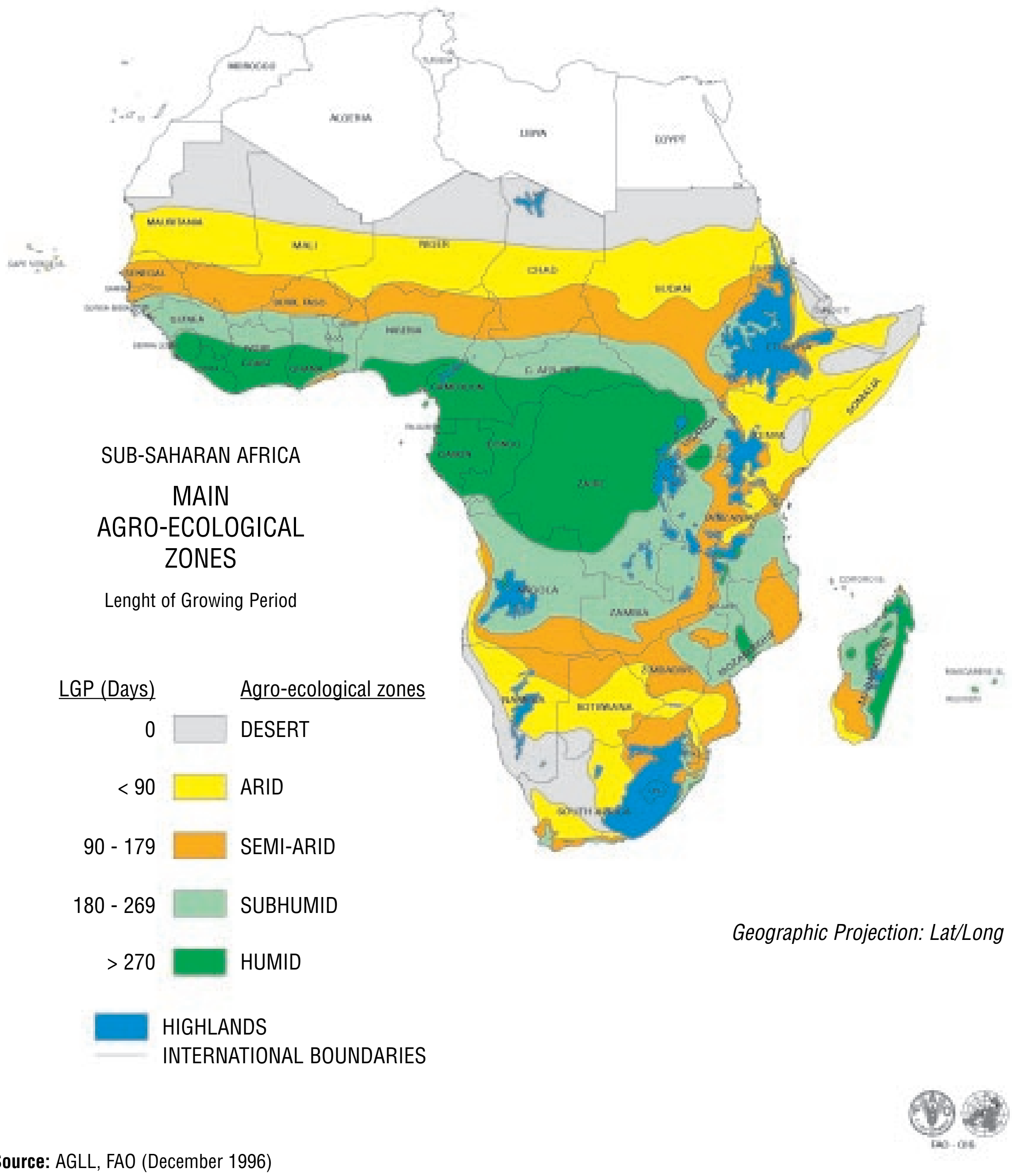
Central Africa: Cameroon, Central African Republic, Congo, Equatorial Guinea, Gabon, Republic of Congo (Zaire).

East Africa: Burundi, Comoros, Ethiopia, Kenya, Mauritius, Rwanda, Uganda. Physiographically and climatically most of Madagascar falls within this eco-region, but has a different farming system.

Southern Africa: *Predominantly subhumid*: Angola, Lesotho, Malawi, Mozambique, Tanzania, Zambia.
Predominantly semi-arid: Botswana, Namibia, Zimbabwe.
South Africa has 70% semi-arid, 30% subhumid, and subtropical temperatures.

Sudano-Sahelian Africa: Burkina Faso, Cape Verde, Chad, Eritrea, Gambia, Mali, Mauritania, Niger, Senegal, Somalia, Sudan.

Figure 8 Map of the main agro-ecological zones in SSA



Source: AGLL, FAO (December 1996)

The humid zone

The largest humid areas in SSA are in West and Central Africa. The rainfall occurs over nine months, with totals exceeding 1500 mm per year (**Table 6**). The major soils are acid with low nutrient levels. An essential feature in this zone is the management of organic matter, as most nutrients are associated with it and thus are concentrated in the surface horizon. Thus, on cultivation, when organic matter is lost by oxidation or through erosion, fertility declines quickly.

The presence of the tsetse fly has been preventing any significant contribution by animals to the farming system. Under traditional shifting cultivation systems, the soil was mostly protected from the erosive force of rainfall by trees and crops. Long fallow under the forest cover allowed quick vegetation regeneration and nitrogen fixation in the soil thanks to its biological activity. But this system can do no more than maintain the initially low fertility levels. Consequently the dominant crops have been root crops (cassava, yams). In the wettest areas (Sierra Leone, Liberia, part of Côte d'Ivoire) rice is grown in the lowlands, without controlled water management. There, the soils tend to be more fertile than the leached upland soils, and several harvests may be feasible before the fallow.

Several perennial tree crops are also well suited to the humid zone. Rubber and oil palm, which are tolerant to acid soils, can be an important source of income. Oil palms have the additional advantage of being a food source, are deep rooted and recycle nutrients efficiently. For example, in deep sedimentary soils in Nigeria, a high population density has been supported by a cropping system in which white yams (*Dioscorea rotundata*) are grown under a cover of oil palms. The soils are generally considered very infertile, but the great depth of soil tapped by the oil palm roots means that although the concentration of nutrients is low, the total amount of nutrients accessible to the palms is considerable.

Cultivation under and around the tree crops is possible and this cropping system may be sustainable. In particular, when new areas of forest have to be cleared by slash-and-burn methods, tree crops may be planted. But if there is no market for the produce, traditional shifting cultivation systems persist, mostly with shortened fallows in transition to semi-permanent systems. In this environment yields fall to very low levels after more than two years of annual cropping, due to the characteristics of the soils (low nutrient levels, acidity), the leaching losses and the vigorous weed growth. High population densities, such as in eastern Nigeria, accelerate such trends.

The search for more productive and sustainable soil management systems in addition to production of perennial tree crops has been pursued for many years, but with limited success. For example, in the Peruvian Amazon (where soil and climatic conditions are similar to those in humid West Africa), yields can be sustained for long periods by application of lime, mineral fertilizers and micronutrients, and by protection against erosion by conservation agriculture. But this requires careful supervision and is not economically viable under existing policies in some SSA countries.

Fertilizers can help to maintain nutrient supplies, but without adequate returns of organic matter to the soil, yields are not maintained. The most efficient method for maintaining organic matter levels in these regions has been some form of *agroforestry*. The effectiveness of the forest fallow can be enhanced by addition of particular tree species. For instance, in southeastern Nigeria, farmers have traditionally planted trees such as *Dactyladenia barteri* and *Anthonota macrophylla* within the regenerating vegetation. The use of bananas and plantains as the final crop in the rotation also provides a productive short-term perennial that protects the soil and tolerates the start of forest growth.

Among agroforestry systems, alley cropping has received most publicity but has not been widely adopted by farmers in SSA. Nevertheless combinations of trees, particularly those which are a source of income, with food crops, fertilizers and conservation agriculture (zero or minimum tillage), seem to offer the best options for establishing more productive and sustainable systems for the humid zone.

Conditions for sustainable food production in the humid zone

Good crop yields and sustainable systems can be obtained in the humid zone with the maintenance of:

- A satisfactory level of organic matter in the soil to mitigate the acidity problems, enhance the activity of soil micro-organisms and maintain a suitable soil structure.
- A sufficient level of nutrients in the soil to support economic crop yields.
- A vegetative cover to prevent erosion.

The subhumid zone of West and Central Africa

In West Africa near the coast, there is a transition from the rainforest to semi-deciduous forest and from a savannah-forest mosaic to wooded savannah grasslands as the length of the dry season increases and the rainfall decreases (**Table 6**).

Shifting cultivation is still common with similar features to practices in the humid zone. The fallows are generally inadequate to maintain soil fertility and crop yields are declining, except where new varieties of better yielding and virus-resistant maize have been introduced and mineral fertilizers are applied.

In the drier parts of the zone, longer grass fallows occur. Animals graze the fallows and some manure may be collected for use on home gardens. Where there is a market for the food crops, as in areas close to major towns, mineral fertilizers may be applied to food crops.

3. Intercropping of *Leucaena leucocephala* (leguminosae) and maize, Ghana.

Many species, including a very wide range of leguminous plants, have been studied as potential improved fallows or live mulch. The costs in terms of land and labour of growing and applying the mulch, however, have discouraged farmers from adopting the system. The alley cropping system used in some places includes the use of rows of *Leucaena leucocephala* with maize and cowpeas planted between the rows. Other species of fast growing woody legumes have also been used. The leguminous trees used so far require adequate levels of phosphorus in the soil, and do not tolerate acidity.

Advantages and disadvantages of the alley cropping system in the subhumid zone

The advantages of the alley cropping system are:

- erosion protection,
- high returns of fixed nitrogen in the tree loppings used as a mulch,
- substantial additions of organic matter to the soil and hence significant improvement of soil properties,
- availability of wood for fuel and building poles.

The disadvantages are:

- a higher labour requirement to manage the trees,
- competition for space, light, water and nutrients between the trees and the crops grown in the alleys,
- an inadequate return from the trees compared with the labour involved in their establishment and maintenance.

Zero tillage with preservation of all crop residues and their use as mulch has been shown to be better suited to the humid and subhumid tropics than use of a plough. However, the difficulties and costs of the transition to new system, including for some tools or equipment, have limited the extent of its adoption.

The subhumid highlands of East Africa

Large areas of highlands are over 1 000 metres above sea level (masl) and several mountainous areas have altitudes from 1 500 to over 4 000 masl. Temperatures throughout the area are relatively low because of the altitude. Where the farmlands are at an elevation greater than 1 500 masl, low temperatures sometimes limit crop yields. Rainfall is from 900 to 1 500 mm/year, and the length of the growing period varies from six to nine months (**Table 6**). Soils (Nitisols, Andisols and some Ferralsols) have relatively good fertility status: Ferralsols and Andisols have good structure and depth, Nitisols have high base saturation, and the lower temperatures slow down the decomposition of organic matter. Hence the highlands are a very desirable human environment, and with population growth these areas are now most densely settled rural areas in Africa.

Within these conditions, permanent and semi-permanent cultivation have long been the norm. Perennial crops such as coffee and tea provide the most satisfactory basis for permanent cropping; bananas and plantains can also serve as both food and cash crops, and provide a cover that protects the soil against erosion. A wide range of food crops is often grown. Although many soils have good qualities, they have often been eroded because of the steeply sloping terrain and the intensive cultivation. Erosion is not the only problem of land degradation. There is also severe nutrient depletion in most parts of the highlands.

In Ethiopia, about 14 million ha, half of the area of the highlands, is significantly eroded, and on two million ha crop production is no longer sustainable. Traditionally, livestock formed an important part of the farming system, with soil fertility maintained by the return of manure to the soil. But grazing land has become increasingly scarce. Short fallows were formerly common, but now are rare. Farmers still endeavour to maintain some stock, fed on crop residues and weeds, but the search for firewood and building poles has led to deforestation in many areas. Inclusion of grain legumes in the cropping system can mitigate the need for nitrogen, but nitrogen fixation and yield are low unless the phosphorus level in the soil is improved. Fertility maintenance is now impossible unless fertilizers are used and farming systems adopted to prevent erosion. Fertilizer use grew rapidly between 1971 and 1996, but fell following the removal of the government subsidy in 1997.

Conditions in the highlands of Rwanda and Burundi are somewhat similar to those in Ethiopia, but population densities are even higher. In Rwanda the population density in the Central Plateau (1 500 to 2 000 masl) is 250 to 800 per km^2. Also the soils are poorer than in Ethiopia, most being Ferralsols rather than Nitisols. Again perennial crops, bananas and plantains have enabled sustainable systems of continuous cultivation to be established in some areas. But there has been continuing land degradation and decreasing yields; which can be considered as contributing factors to the internal conflicts and forced migration from Rwanda and to the problems in Burundi.

In Kenya most of the population is concentrated in the highlands. In parts of Machakos District (one of the most populous), investments have been made in erosion control and establishment of cash crops as economic conditions improved due to the proximity of Nairobi and the construction of better roads. Rainfall is collected from the roofs of the cattle sheds for animal use, and zero grazing is becoming increasingly important for the sustainability of the system. The use of fertilizers was increasing, but withdrawal of subsidies has led to high prices and decreasing use. Farm incomes are still too low to support the system but, when external income is found, increased investment in the farms becomes possible; otherwise population growth will entail increasing erosion.

In some highlands of Uganda similar problems occur, and as in Rwanda, pressure on land has led to migrations sometimes resulting in conflict. In central Uganda there is a high degree of dependence on bananas as the major staple (nearly 30 percent of the cultivated land). Under banana, the soil is protected and, where the crop residues are returned to the soil, the rate of nutrient removal is relatively slow. However, continuous production over many years has led to falling yields. Attempts to maintain them have mostly failed, although tall grass mulches and potassium fertilizers have given large yield responses. As a result, much banana production has moved to western areas and the area of root crops (cassava and sweet potatoes) has increased. But these crops will almost certainly lead to a more rapid rate of soil degradation, even though in the short term they may increase food availability. In parts of western Uganda, where land pressure is less, the cattle provide manure and grass is available for mulch.

Maintaining soil fertility in the subhumid highlands

In the subhumid highlands, the maintenance and improvement of soil fertility will depend on the use of mineral fertilizers and lime, cultivation of green manures and cover crops, use of agroforestry, and with integrated nutrient management wherever it is possible to collect manure or other sources of organic matter.

The subhumid and semi-arid zones of Southern Africa

The vast areas from south of Rwanda to the Cape of Good Hope are mostly at altitudes between 500 and 1 000 masl, and have lower rainfall than the highlands (**Table 6**). Some of the area is subhumid but most is semi-arid. The smaller arid areas are discussed later.

The natural vegetation of the subhumid zone is a wooded savannah, with grassland becoming dominant as the climate becomes drier. Animals have always been an important part of the farming systems, although their numbers have been decreasing with the growth in food demand. The dominant soils in the semi-arid areas are Arenosols, with low inherent fertility. As the climate becomes wetter, Luvisols, Ferralsols and Cambisols dominate, of slightly higher inherent fertility but still poor. Degradation by erosion and nutrient depletion is common throughout the region, particularly in areas where population density is relatively high.

Long fallow shifting cultivation still occurs, but much of the subhumid region is now under semi-permanent mixed animal-crop systems. In some of the wetter areas perennial cash crops such as coffee are grown, and a permanent system has been established with annual crops on large commercial farms (>1 000 ha) in Zimbabwe and South Africa. In most of the region, little income can be generated from annual crops as farms are less than 5 ha and much of the produce is consumed by the family. In Zambia and South Africa, the development of mining and other industries has provided opportunities for migrant labourers. Where there has been sufficient income from external sources, fertilizers and other inputs have been purchased, and permanent cropping, in particular cash crops, has emerged.

Zimbabwe, which is often considered to be the potential source of food for the rest of Africa, and Malawi are both "at risk", in terms of using mineral fertilizers to increase crop production. This is because liberalization of economic policies has led to higher prices and lower use of fertilizers. Animal manure has been used traditionally to help maintain soil fertility, but grazing land has become scarce where the manure is needed.

Maize yields are almost universally less than 1 tonne/ha. When high inputs can be purchased (fertilizers, mechanized land preparation, etc.), with acidity control and erosion prevention (as in commercial farms of Zimbabwe and South Africa), yields in excess of 4 tonnes/ha can be achieved in spite of the low and erratic rainfall. By contrast, in the communal areas (farm size < 5 ha), traditional farming systems fail to provide sufficient income and much of the farming remains at the subsistence level with yields from 0.2 to 1.5 tonnes/ha.

4. Covering ground with straw to preserve moisture, Malawi.

One of the most important issues in these areas is to ensure that the rain falling on the soil enters where it falls, in order to maximize the water available to crops and to avoid runoff and erosion. Contour bunds and grass strips control the movement of runoff water and so prevent erosion, but do little to assist water entry where the crop requires it. The first requirement is to avoid crust formation on the soil surface by maintaining a cover (live plants or mulch). But in the driest areas most plants cannot maintain a cover during the dry season, and it is difficult to preserve organic mulch because it is often destroyed (burnt to renew the grass species, grazed or eaten by termites).

Early cultivation before the wet season (or just at the beginning) to break a crust is therefore a common practice. Conventional tillage using the mouldboard plough or large discs causes soil degradation, and conservation tillage methods are now promoted. The alternatives developed in Zimbabwe are no-till tied furrow and no-till tied ridge systems.

Lack of individual title to land is a major factor limiting the adoption of more productive land management methods. Legal tenure of the land and the creation of a commercial market for land are necessary before banks can provide credit to farmers on the basis of land ownership. In areas of uncertain rainfall and wide annual variations in yield, a sympathetic and flexible loan system is essential if land productivity is to be increased.

The Sudano-Sahelian zone

The Sudano-savannah zone is generally regarded as moist semi-arid and the Sahelian zone as dry semi-arid (**Table 6**). In both zones water availability tends to be the critical factor in determining what crop and animal production systems are suitable, and the water availability depends on the soil and landscape factors as well as rainfall.

In the driest parts of the **Sahel**, extending to the arid areas, nomadism is still prevalent. From the driest to wetter areas, crop production plays an increasing role in the system. In the past, long fallows gave the sparse tree and bush vegetation a chance to regenerate, while livestock were taken elsewhere to graze (a system sometimes referred to as semi-nomadism). As population density has grown, the opportunities to move cattle away to new pastures for sufficiently long periods have gradually disappeared. Fallows have become shorter and, though many practices to restore soil fertility have been proposed, there has been little success in terms of farmer adoption.

Food production systems are based on the use of fallows to maintain organic matter, the use of animals as a reserve of food, a source of wealth (and prestige) and of manure, and the use of cultivation methods to maximize water entry and storage. As in semi-arid areas of southern Africa the long dry season means that, for several months each year, little vegetation is present to protect the soil and erosion is a widespread problem.

5. Integrated agro-sylvo-pastoral project in Senegal.

The farmers' priorities are always associated with endeavouring to ensure that they will have enough to eat in the coming season. In the past, in a poor season this meant migration to areas with better rainfall. As population density has increased the extent of the migrations has decreased, and the importance of crop production increased. But with the low rainfall and poor soils, yields are usually low. The bulk of crops produced in the Sahelian zone are normally used for subsistence.

Similar constraints exist in the moist **Sudano savannah** zone, but with the slightly more certain and higher rainfall, crop production is more assured. Cotton is grown as a cash crop, which enables input purchase (better varieties, fertilizers, pesticides and mechanized tillage). Cotton has usually been planted on the better land, often with some form of erosion control. However, cotton yields did not improve everywhere. In upper Casamance in Senegal and in the Sudan savannah zone, yields fell between 1970 and 1980, due to a high population density and more competition for the better land and for inputs between cotton and food crops.

In the moist semi-arid zone, in northern Nigeria, there is also a very high population density. The demand for food in the city is so important that food crops have achieved the status of a cash crop, and small quantities of mineral fertilizers may be used to supplement animal manure. Together they are sufficient to maintain yields of maize and sorghum at about 2 tonnes/ha. Animal manure is so much in demand that it can be bought in the Kano market. The sources of manure are local cattle and small ruminants, fed largely on the crop residues and stubble left on the fields in the dry season and sometimes from hedgerows and erosion barriers planted around the smallholdings. With these inputs, the relatively cheap labour available around the overcrowded city, and an assured market, a relatively sustainable continuous production system appears to have been established.

Experiments on the research stations in the Sudano-savannah zone showed that mineral fertilizers alone cannot always sustain yields, but that this is possible when both fertilizers and organic manure are used in an integrated system. But research stations use methods to ensure timeliness of cultivation and sowing that may not be available to the farmer. Improvement of the natural fallows has been pursued in the savannah and in the forest zones, but with similarly limited success. The use of fertilizers to improve the quality and productivity of the natural grasslands has been promoted but has not been adopted, as the economic advantages are not immediately apparent. The use of trees as windbreaks to reduce wind erosion, and grass strips to control water erosion has received government support. These practices are now pursued extensively, where the trees and grasses also produce additional animal feed.

The arid zone of East and Southern Africa

In spite of the very low and erratic rainfall there is normally sufficient vegetation to allow cattle grazing. But as the rainfall is uncertain, cattle must be moved to wherever feed is available and nomadism is therefore common.

When the human and animal populations increase two problems arise:

- All the animal feed will be consumed to the point where the natural vegetation does not regenerate following a rain.
- The sources of water for humans and livestock become inadequate. The areas near water supplies become seriously degraded as large numbers of animals concentrate in their vicinity. Without additional water little can be done to improve productivity of these regions.

The first step towards improvement has to be a restriction on the number of animals, and then proper management of access to watering points. But a restriction on the number of animals mean that population is also restricted, and so emigration from these areas is often the only solution. Where this has entailed movement across national boundaries, conflicts have arisen, as in the Horn of Africa.

In Eritrea, overgrazing has seriously degraded the natural vegetation and erosion has devastated large areas. Then people had no choice but to move or to be supported mainly through food aid. The annual food deficit in the country between 1991 and 1996 ranged from 36 to 84 percent with an average of 64 percent.

Eritrea has a small area of highlands with better rainfall, but these areas have become overpopulated, and there is an urgent need to increase production and to control soil degradation. Even in these areas rainfall is still low (of the order of 400 mm per year) and erratic. Methods for raising productivity are similar to those needed in Ethiopia. There is scope for water harvesting and irrigation development.

6. Water harvesting in Eritrea: a small dam.

Experience to date has shown that almost all of the major dams constructed have been completely silted within a few years because of the severity of soil erosion in the catchment areas. Some of these areas are in Ethiopia, so that the problem in the catchment areas cannot be solved by Eritrea alone. A further problem is that many of the potentially irrigable areas have saline and sodic soils.

In Namibia, the problems are less severe, as the present population density is only two persons/km^2 compared with 28 persons/km^2 in Eritrea. There is also a significantly larger area in the semi-arid zone, where crops could be produced by irrigation. However, much of this land has been assigned in large blocks for commercial production and problems have already arisen within the communal areas. As in other parts of the arid zone, the problems of increasing productivity cannot be easily resolved without access to additional water. While there are approximately 3.6 million ha of land classified highly suitable for irrigation, the available water is so limited that only 45 000 ha could be irrigated.

Increasing food production in the arid zone

Development of water harvesting and other soil and water conservation (SWC) techniques to make maximum use of the limited rainfall provides the only realistic option to increase production of food crops in these areas.

Successful soil fertility management schemes

The following are indicative examples of successful soil fertility management schemes and projects (extracted from FAO. 1999c).

The programme of farmers' associations in Uganda

This programme was an exception, in that it was not funded by the Government or by a donor. Information about how to make the Nangabo Association's farming system more productive was obtained from:

- the radio programmes broadcast by Radio Uganda,
- contacts with other progressive successful farmers and with extension agents of the Ministry of Agriculture,
- Makerere University and the national Agricultural Research Organization. The ease of access to Kampala enabled the Association to invite staff from these organizations to visit them, and discuss at first hand how to improve the management of their farms.

The proximity of the area to a major market in Kampala, 15 km distant and connected by good roads, enabled the Association to obtain good prices for their produce.

The soil fertility management practices introduced by the farmers were obviously socially acceptable and while the market in Kampala continues to grow, economically viable. Alternative employment was available in Kampala so that almost half of the income of the region is derived from non-agricultural activities.

Prior to the formation of the Association, the area had been used primarily for banana production, the local staple food, but as yields declined due to mining of the soil nutrients, and probably to nematode and other pest problems, root crops became more important. The major improvements in productivity were brought about by crop rotation, the use of mulches, manure and fertilizers, and fallow. With a bimodal rainfall pattern, farms of over two ha, deep soils and a farming system based on bananas, productivity rose rapidly, and the area has become relatively prosperous. The banana crop itself gives some protection from erosion and, when combined with mulching and contour bunds, erosion is no longer a problem. The fertility of the soils has started to increase, and the changes appear to be sustainable.

The SCAPA project in the Arusha area of Tanzania

The Soil Conservation and Agroforestry Programme (SCAPA) in the Arusha area of Tanzania is introducing improvements that are promising to become sustainable. Perhaps of greatest importance is the use of village soil conservation committees and village extension officers, ensuring involvement of the farming community in all aspects of the programme. The project is based on the introduction of soil and water conservation techniques, agroforestry, livestock husbandry and crop management. The conservation techniques mainly rely on the use of contour bunds on which trees or elephant grass are planted. These not only reduce soil erosion but conserve water. The local communities provide the labour. The tree seedlings (over 1 million were distributed) and the grass planting materials were funded externally. However, it is expected that the farming communities can produce the planting materials. It is also still unclear how the overstocking problems of the pastoral areas will be resolved, although the enhanced production of feed from the trees and grasses established on the bunds will help to reduce the grazing pressure.

The Conservation Tillage project for sustainable crop production in Zimbabwe

The Contil project has been quite successful. An important element in its success has been farmer participatory research in establishing the most suitable methods of productivity improvement. On-farm trials to identify the most suitable animal-powered conservation tillage methods were managed by farmers, who selected from the options offered by the researchers. In the subhumid regions no-till tied ridging offers the best opportunity for a sustainable increase of productivity, whereas in the semi-arid regions mulch ripping is the most favoured option. However, mulch ripping is only viable where sufficient residues are available to provide mulch. Commonly the residues are needed as animal feed, and then tied ridging has to be used. The largest yield responses to the cultivation system are obtained when it is used in conjunction with fertilizers. The benefits in yield of cotton have been demonstrated over eight seasons from 1984 to 1991. Recent changes in policy with regard to the removal of subsidies on mineral fertilizers may well lead to the system becoming economically unsustainable. Small and fragmented holdings make it difficult to use the cheaper methods of large-scale tillage, which have made the large commercial farms successful in the past.

The project at the Machecheta agroforestry site in Malawi

This major project is evaluating a wide range of technologies, divided into those that have a short, medium and long-term pay-off. Alley cropping falls into the second category, interplanting cereals with *Faiedherbia albida* falls in the third category; undersowing and improved fallows have a short term pay-off.

7. Incorporating crop residues in the soil to improve soil fertility, Malawi.

In Malawi, it is concluded that a combination of all three types of resource conserving technologies is needed for sustainable agricultural production, and that for food security they will need to be augmented with "modest mineral fertilizer inputs". It is not yet clear, however, what policies will be needed to make the systems sustainable.

Sustainable crop production in Kenya and Zambia

In western Kenya, in an area where the population density exceeded 500 persons per km^2 and with bimodal rainfall in excess of 1 200 mm per year, a sustainable increase in crop production has been demonstrated. A number of options were made available to farmers. The most widely adopted technologies are the use of active rock phosphate with improved fallows of *Sesbania* or *Tithonia*, and additional plantings of the fallow species as contour strips, boundary markers or field borders to control erosion.

There is a significant increase in profitability, but the main benefits are often medium rather than short term. Thus for farmers with an alternative source of income they offer a considerable advantage which can be realized without external financial assistance, but these farmers are only about ten percent of the farming community. For the others some form of initial financial assistance will be necessary.

8. A good crop of maize grown in Zambia under improved management practices: spacing, weeding, manure and fertilizer application.

A similar study was conducted in Zambia, under monomodal rainfall of less than 1 000 mm per year on poorer soils (except for a higher phosphate status). Population density was only 20 to 40 per km^2. The existing farming system involved the use of grass fallows of five years duration. It was shown that *Sesbania* or *Tephrosia* grown for two years could replace these fallows, so that average annual income was significantly increased. Provided that the planting material can be made available, a more productive and sustainable system could thus be established without external inputs. Extra income was considerably greater, however, when mineral fertilizers were used in conjunction with the leguminous fallows.

Rice production in the humid areas

9. Irrigated rice fields and small rainfed vegetable gardens (maize, potatoes, vegetables) in Madagascar.

A sustainable system in the humid areas is rice production with controlled water supplies. In Asia such systems were developed many centuries ago. Their productivity has been greatly raised by the introduction of varieties able to respond to higher nutrient levels and the use of fertilizers to increase the level of nutrient supply. The success of the rice production systems of Asia has grown from the indigenous knowledge and major labour inputs of the farmers who developed the rice fields and water management systems. More recently, irrigation systems based on dam construction to assure the water supply and credit systems to enable farmers to purchase the fertilizer and other inputs required to increase yields have given rise to major production increases.

There are economic difficulties related to irrigation development in sub-Saharan Africa. Nevertheless rice production under flooded conditions offers a major opportunity to develop sustainable production systems. Rice production in Africa has been increasing more rapidly than that of any other crop. Madagascar long ago developed systems similar to those of Indonesia. There is great potential for expansion of sustainable rice production in SSA.

The Government scheme in Burkina Faso

This scheme has yet to be evaluated at the farm level. It involves the distribution to farmers of large quantities of the indigenous rock phosphate, which is of low quality. This will slowly improve soil phosphate levels over the years, which would help all crops, particularly legumes, and slowly improve nitrogen fixation. It will also be possible to stimulate the release of phosphate from the rock by use of organic amendments. The implementation of Government plans to distribute urea fertilizers as well would raise crop production in the short term, but the measures may not be sustainable.

Best practices in soil and water conservation

The World Overview of Conservation Approaches and Technologies (WOCAT) is a programme initiated in 1992 by the World Association of Soil and Water Conservation and the Centre for Development and Environment, University of Berne (Switzerland) in collaboration with several international institutions, including FAO. It aims to assess what measures are being taken against degradation (mainly erosion), to establish a database and disseminate information on proven soil and water conservation (SWC) technologies.

WOCAT has developed a collaborative network and a standardized framework for the evaluation of SWC, which includes questionnaires on technologies, approaches and maps. These questionnaires cover many aspects of SWC activities as well as the biophysical and socio-economic environments. Through regional workshops, specialists from several countries collect and exchange information and experience. Such workshops have already been organized in SSA.

The overall goal of WOCAT is to contribute to sustainable utilization of soil and water:

- collecting and analysing information on SWC technologies and approaches worldwide, and
- presenting the collected information in computer databases and an expert system, and in the form of handbooks, reports and maps in a clear, precise manner readily accessible to SWC specialists and policy-makers worldwide.

Need for action for sustainable soil fertility management

The importance of holistic and integrated approaches

Almost all of sub-Saharan Africa needs to increase the production of food crops, and this need will become more urgent during at least the next twenty-five years.

10. Land preparation in "half moons" for soil and water conservation, Niger.

Part of the need will be met by the cultivation of more land, but most of the need must be met by raising the productivity of land already cultivated. The productivity of much of the new land is likely to be low, as most land of high production potential is already cultivated. Measures to increase the productivity of both presently cultivated and new land are urgently needed.

To meet the rate of population growth, yields must grow at a rate considerably greater than today, even to maintain present low nutritional standards. The extra yield must also be obtained without causing further degradation of the soils, and indeed the fertility of the soils will have to be raised.

First and foremost, the farmers (men and women) will need to make the necessary changes, and governments must assist them in developing their farming practices in such a way that production is increased on a sustainable basis.

Ensuring that the options for increasing productivity are available is a task for scientists concerned with agricultural production and land management. Social scientists and economists must also participate in the research to ensure that proposals for change are economically viable and socially acceptable. Also, all the factors involved in improving soil fertility and soil productivity should be integrated. Measures to prevent

11. Harvesting crops in the "half moons" in Niger.

degradation as well as methods to increase productivity must be included. Integrated and holistic approaches (and not segmented technical interventions) of soil and nutrient management for conserving soil quality and enhancing its productivity are required.

Many long- and short-term experiments in SSA, and elsewhere in the tropics, have shown the need to maintain soil organic matter as well as nutrient status. The organic matter provides a balanced supply of macro- and micronutrients and helps maintain and improve the physical and biological condition of the soil.

Thus, the approaches to more productive and sustainable systems must be holistic in terms of involvement of all the stakeholders, including the farmers, and must integrate the various factors and techniques that are to be used.

Monitoring and strengthening efforts to combat land degradation

Comprehensive and integrated action has to be taken to combat both direct and underlying causes of land degradation, to avoid the destruction of land resources and mitigate poverty, economic losses at national level, and negative impact on the global environment.

This implies that cooperation and tools will be necessary to enhance the knowledge and monitor the status of land degradation and to strengthen the efforts for combating degradation; for example:

- Establishment of a regional or subregional Collaborative Programme and guidelines for *in-depth assessment* of land degradation, which would include survey of the present state of degradation and monitoring of soil changes.
- Study of the economic and social effects of degradation upon the people, which will require collaboration between land resources and management specialists and social scientists.

In this respect, initiating regional and/or subregional programmes on the assessment of soil degradation and its impacts in SSA (in line with ASSOD "Soil degradation in South and South-East Asia") would be useful. Moreover, there is a need for harmonization of methodologies and promotion of quantitative assessment of the impacts of degradation on productivity at national or subregional level, using the 1:1 million SOTER database.

continue...

- Design and implementation of programmes and measures to combat land degradation, which would include:
  - Clarify institutional responsibilities, and perhaps the establishment of high-level advisory committees on policies related to land conservation, rehabilitation and sustainable use.
  - Identify focal institutions and coordination mechanisms for land degradation assessment and monitoring.
  - Identify priorities with respect to type of degradation and critical "hot" spots.
  - Plan and implement programmes for controlling degradation and for enhancing productivity, such as watershed land management and conservation projects, community-based natural resources management projects "gestion des terroirs", National Action Programmes for combating desertification and drylands development projects.

The World Soil and Terrain Database

The World Soil and Terrain Database (SOTER) is an initiative of the ISSS and the approach was adopted at the 13th World Congress of Soil Science in 1986. Under a UNEP project, the SOTER methodology was developed in close cooperation with the Land Resources Research Centre of Canada, FAO and ISSS. In 1995, UNEP, ISSS, FAO and ISRIC jointly published the Procedures Manual for Global and National Soils and Terrain Digital Databases, with international recognition.

The programme provides data on natural resources that can be readily accessed, combined and analysed from the point of view of potential use and production, in relation to food requirements, environmental impact and conservation. The approach is based on the mapping of areas with a pattern of landform, morphology, slope, parent material and soils at scale 1:1 million. Each SOTER unit is linked through a geographic information system (GIS) with an electronic database containing all available attributes on topography, landform and terrain, soils, climate, vegetation and land use. Thus each type of information or each combination of attributes can be displayed spatially as a separate layer or overlay or in tabular form.

ISRIC, UNEP and FAO have joined resources to provide a world SOTER map at scale 1:5 million by the 17th ISSS Congress (2002, Thailand). They also receive support from other international organizations to develop SOTER databases for specific regions. The ongoing and planned activities related to SOTER are presented in **Table 7**.

Table 7 Operational plan for world SOTER: 1995–2002

Region	Status	Main Agencies Involved	Published
Latin America and the Caribbean	Published	ISRIC, UNEP, FAO, CIAT, national soil institutes	1998
Northeastern Africa	Published	FAO–IGAD	1998
South and Central Africa	Ongoing	FAO–ISRIC–National Inst.	2000
North and Central Eurasia	Published	IIASA, Dokuchaev Institute, Academia Sinica, FAO	1999
Eastern Europe	Finalized	FAO–ISRIC–Dutch Government–National Inst.	2000
Western Europe	Ongoing	ESB–FAO–National Inst.	2001
West Africa	Proposal submitted	Awaits funding (ISRIC, IITA)	
Southeast Asia	Proposal discussed	Awaits funding	
USA and Canada	Own Effort		
Australia	Own Effort		

Although the information is collected according to the same SOTER methodology, the specific detail of information in each region results in a variable scale of the end products presented. National SOTER maps have been prepared, with ISRIC's assistance, for Kenya (1:1 million), Hungary (1:500 000) and the Syrian Arab Republic (1:500 000).

Policy issues and government responsibilities

Methods for establishing truly sustainable systems for the lower rainfall areas of high population density need much further research. Considerable government intervention would be required to facilitate the provision of the necessary inputs to grow adequate food for the existing population.

The problems are perhaps less acute in the more humid regions, where perennial tree crops protect the soil and recycle nutrients. They can also provide a source of income that can be reinvested in methods to increase yields and soil fertility. But the example of cocoa farming in Ghana is worth quoting. By making cocoa seedlings widely available to smallholders, a successful industry was established. As long as the economic benefits flowed at least in part to the farmers, the industry and the country thrived. When the Government controlled the farm-gate price of cocoa, shifting the economic benefits, the industry collapsed.

Even a biophysically sustainable production system will not be economically and socially sustainable unless government policies are attuned to the needs of the agricultural community and governments invest in capacity building.

Economic development

Improvements in agricultural production depend not only on the establishment of technologies for increasing yields, but also on many other aspects of economic development. As well illustrated by the example from the Machakos area, Kenya, alternative employment opportunities, roads, access to markets and price differentials are all important. In spite of many years of Government efforts to reduce soil degradation and increase agricultural productivity in this region, there was little impact until all of these aspects became favourable. Then, production increased, the various measures needed to reverse soil degradation were introduced and the land recovered from many years of previous mismanagement.

Use of fertilizers

The development of fertilizer use in SSA has been slow, despite the large yield increases demonstrated in field experiments (research stations and farmers' fields). The main reason is the high price of fertilizers relative to the price of food crops. Fertilizer prices in most SSA countries are even higher than in other places in the world. Where fertilizers have been subsidized, their use has usually increased rapidly, but when subsidies have been removed there has been a substantial decrease in use.

At the present time soils continue to be depleted of nutrients. Rather than increasing the productivity of soils, present practices continue to degrade them. Unless these trends are reversed there will be continuing food shortages, and decreasing contributions from agriculture to national income.

Research and technical services can also help in increasing the efficiency in terms of response from the crop per unit of fertilizer used. This may be obtained by tailoring the kinds and quantity of fertilizer and the time and method of application more specifically to the climate, soils and crops. This will require more research efforts and innovative, participatory extension approaches, such as **farmer field schools**.

An alternative is to increase the price farmers receive for their produce. This creates a problem for governments seeking ways to keep food prices low. There are no easy solutions, but the appropriate course of action may be to maintain partial subsidies under specific biophysical and socio-economic conditions. In times of shortage governments may import food or receive food aid. Both measures will keep prices down, to the detriment of the farmer who has produced a crop.

Land tenure rights and access

A major problem is that farmers are reluctant to invest in improving soils unless they are sure that they and their heirs will retain rights to the use of the land. Although the need for security of land tenure is generally emphasized, legal title and sales of land can mean that the few with large financial resources acquire large holdings, which may be developed for private advantage rather than that of the community.

Also in many of the drier areas, freedom of movement of cattle and people has been essential for the survival of some communities. Unless restrictions on movement are accompanied by policies which ensure that an alternative economically viable and socially acceptable way of life is offered to those affected, the problems created are likely to outweigh any advantages.

The development of biological capital - planting of trees, grassed contour banks, establishment of nurseries for the production of seeds or seedlings of new and improved species or varieties - may be more readily funded from local resources, but will often require some external inputs. This may be done at little cost, for instance if the local community is given the necessary land rights and the assurance of social stability.

Fragmentation of holdings and migration

As small farms are further divided, the size of holding becomes less able to support a single family. In desperation, parts of the communal grazing lands are cultivated, inevitably resulting in disputes. When problems become too difficult, large groups may migrate to other land, or migrate to cities, adding to the unemployed.

To mitigate or resolve these problems, soil and water conservation measures should be in place. The local community may finance and implement such measures, as in Machakos, Kenya but, more often, government support or credit at reasonable cost will be required.

Stakeholders participation

As discussed at the Harare Expert Consultation in 1997, successful, sustainable farming systems have been developed where farmers were involved at all stages. Among the successful examples is that of the farmers' association formed in Uganda. There are many forms of farmer and community associations that can contribute to agricultural development. Farmers themselves are among the most effective extension agents.

12. Sustainable management of natural resources by smallholders in a participatory programme (assisted by UNDP and FAO) in Malawi.

To ensure that an agricultural system is sustainable it is often necessary that a large land area be managed appropriately. Most commonly the catchment unit has to be managed so that the upper slopes are not eroded and rainfall is retained in the soils of the upper watershed, to avoid flooding and sedimentation in the lower parts of the catchment. Protection of the upper parts of catchments from agricultural use, which may lead to erosion, has often been enforced by government edict. But when farmers need land to survive such edicts tend to lose their authority. If district or regional councils - in which farmers constitute a majority - have the right to determine the management of the catchment, it is of course essential that the farmers and others have access to the necessary advice. National or international consultative bodies may be needed where there are common interests in the management of land units across regional and national boundaries.

The national research and extension services, often in association with international and other organizations, have a key role to play in ensuring that all the options for improvement of the productivity of farms and the conservation of resources are known to the farmers. The "Contil" projects in Zimbabwe are good examples of how this may be done.

Many **NGO**s work more closely with the farming communities than government advisory services, and can help both farmers and national authorities to a better understanding of local problems. Similarly the private sector has a role to play, such as to provide fertilizers or soil amendments suitably packaged and clearly and fully labelled, at competitive prices. In order to meet the needs of farmers, fertilizer companies must have good knowledge of how fertilizers should best be used in association with manures and other organic amendments.

Involvement of farmers in research is a powerful tool in increasing farmers' interest and understanding of how to make the best choices from the options available. Knowledge has to be shared among the research, extension services and the commercial organizations and information has to be exchanged with farmers' organizations. For a holistic approach to be successful, with information shared freely, it is essential that there is information to be shared. National and international organizations have a role to play in establishing the mechanisms for these exchanges of information.

Research needs

Indigenous knowledge is founded on long experience, but may not be appropriate to changing circumstances. Formal research then has to offer options for responding to the changes. Considerable information is available about soil management practices to increase productivity. But information is lacking regarding adaptation of methods and regarding the best policies to make them socially acceptable and economically viable. National research organizations will need help and assistance in conducting the necessary studies. Networks need to be established or strengthened to enable research results to be obtained and shared. The research must include social and economic issues to complement the information on land and enable extrapolation of the results.

The sources and qualities of organic manure and amendments need further study. Animal manure is seldom collected and handled in ways that retain its quality. The trees and other species that are used as sources of organic amendment merit much further attention. Also, more should be known about the amount and the quality of biomass produced, the conditions in which the trees perform well, the value of the wood for other uses, the value of fruit produced and the conditions of use. While legumes have been favoured because of their nitrogen fixing ability, non-legumes often have other desirable features such as the ability to scavenge phosphate from the soil, as shown by *Tithonia diversifolia* which forms a useful hedge species.

The rates of degradation and recovery of different soil types in different environments should be experimentally studied. This requires that long-term experiments be established and monitored. These experiments need to be supplemented by a wider programme of monitoring soil changes across a broad range of soil conditions. Therefore, strong government commitments are necessary to support the development of the agricultural sector and the national research and extension services; help from international and non-governmental organizations must also be encouraged.

The Soil Fertility Initiative

The key to restoration and enhancement of soil fertility is the collective responsibility of many parties, including governments, inter- and non-governmental organizations and all stakeholders in the food production process. Accordingly, the World Bank, in collaboration with FAO, have provided the leadership to assemble and coordinate a global effort that will focus on reversing the detrimental effects from soil degradation and nutrient depletion in sub-Saharan Africa. Other international organizations currently involved in the initiative are ICRAF and IFDC.

In support of the larger goals of poverty alleviation, food security and environmental protection, the major objective of the Soil Fertility Initiative (SFI) is to improve the productivity of cultivated lands and the revenue of farmers through a combination of technology adaptation and policy reform.

A workshop was organized in Togo (April 1997) with the participation of 120 delegates representing 22 countries in SSA, subregional institutions, NGOs and the private sector, as well as international development and research organizations, including FAO. The workshop re-emphasized the need for recapitalization, maintenance and improvement of soil fertility as a basis for long-term food security. After a series of discussions and refinement, involving FAO, the **"Framework of National Action Plans for Soil Fertility Improvement"** was developed.

The thrust of the SFI

- **Dissemination of appropriate technologies** for the restoration and maintenance of soil fertility and intensification of agriculture through an integrated approach using organic and mineral fertilizers, erosion control, land and water management to enhance food security and farm income.
- **Promotion of enabling policies** that will correct market and institutional constraints to improve soil productivity.
- **Development of programmes** that will provide incentives and ensure the full participation of individual farmers and communities for the restoration of soil fertility and improved land management.

The SFI was officially launched during the World Food Summit, November 1996.

Salient features of the framework and preparation of the SFI - NAP

A National Action Plan (NAP) promotes actions, capital and labour investments for soil fertility improvement and for the supporting sectors (improved availability and accessibility of soil amendments and inputs for agricultural intensification, etc.), and for alleviating socio-economic and technical constraints.

Implementation of national workshops and working groups

The workshops will permit identification of the needs for soil fertility improvement, create general awareness and establish working groups which include all stakeholders (NGOs, farmers groups' representatives, agricultural input producers and distributors, research and extension services, policy-makers and multidisciplinary technicians). These groups will assist in the preparation of the NAP.

Identification of ministries, institutions and public services to be involved

The creation of a conducive environment and input and output market development requires the competence of more ministries than just the Ministry of Agriculture. Other ministries, therefore, will have to play a role in the SFI, such as ministries of environment, forestry, finance, planning, science and technology and social affairs. Arrangements also need to be made to clarify the responsibilities and ensure operational involvement of various institutions at national, subnational and local level.

Preliminary data and studies

The data required for the preparation of a NAP for SFI include: geographical and agro-ecological characteristics, socio-economic and agricultural data as well as information on current agricultural policies and strategic orientation. Studies and agricultural constraint analysis will also be required. The constraints and possible solutions related to soil fertility improvement will depend on the national, subnational or local socio-economic and agro-ecological conditions in the country. The strategies to implement the NAP will vary from one country to another, depending on the extent and magnitude of soil degradation and nutrient depletion, local availability of inputs, other soil management technologies, available means and donor commitments.

The implementation of the NAP

Once the strategy has been adopted by the government, implementation will involve the participation of all stakeholders and support by donors or lending agencies. The real improvers of soil fertility (the farmers) and the private sector can act effectively once the policy environment and market development are in place.

Indicators for monitoring NAP

The performance of the NAP also has to be monitored and evaluated. This would include a core set of “Indicators” including:

- **Physical indicators** such as nutrient balance, land use systems and intensity, land cover, increased use of amendments, organic and mineral fertilizers, and measurements of soil fertility parameters (pH, CEC, OM, nutrient status).
- **Economic indicators** such as trends in crop yield, livestock productivity, output levels, prices and rural income.
- **Social indicators** such as rate of adoption of improved soil management practices by farmers and farming communities, increased stability of rural communities (e.g. reduced migration).
- **Environmental indicators** such as rate of deforestation, state of rangelands and erosion, carbon sequestration.

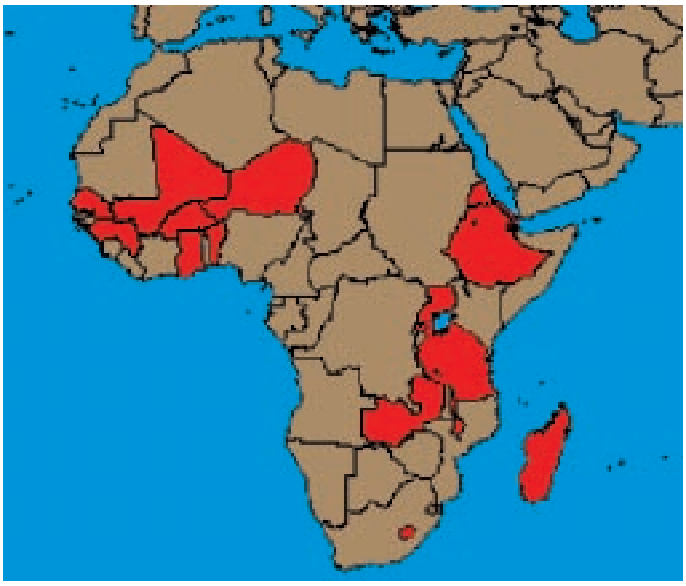
Strategy, synergy and coordination

The Plan of Action adopted by the World Food Summit called for concerted efforts at all levels to raise food production and increase access to food. It focused on the low income food deficit countries (LIFDCs), particularly in Africa, with the objective of reducing by half the present level of malnourished people in the world by the year 2015.

The collaboration of WB and FAO has been strengthened in the framework of the Special Programme for Food Security (SPFS). SPFS promotes rural development and food security programmes, through implementation of local projects (low-cost small-scale irrigation, water control, improved land management and soil fertility enhancement, crop intensification and diversification), analysis of policy constraints, policy reform and capacity building.

WB and FAO (TCI and AGL divisions) have launched the preparation of the SFI National Action Plans in some 20 countries in SSA (**Figure 9**).

Figure 9 SFI participating countries in SSA



Benin	Ghana	Malawi	Senegal
Burkina Faso	Guinea	Mali	Tanzania
Eritrea	Lesotho	Niger	Uganda
Ethiopia	Madagascar	Rwanda	Zambia

The projects under SFI-NAP are to ensure participative land management and fertility improvement, drawing on the experiences of the WB and FAO-assisted projects, such as "gestion des terroirs" – community-based natural resources management; improved land husbandry methods; and farmer field schools (an instrument for participative development of site-specific integrated soil and nutrient management and conservation).

SFI strategies are bound to differ between countries and regions and tend to be very site-specific. Population density, farm size and the cost of delivering imported fertilizers to agricultural areas have a major bearing on the choice of strategies, as do, of course, soil conditions.

Current common understanding of the SFI

Participants in the informal SFI Consultation (Rome, November 1998) agreed that the SFI activities should result in short-term economic benefits to farmers as well as in the longer-term restoration of the nutrient capital in the soil. Policy and institutional improvements are essential to the success of SFI.

- The SFI must be country-driven and national ownership should be ensured from the onset. National institutions and farmers' groups need to be the driving forces of the SFI in each country. All stakeholders should be involved in all phases of action. The formulation of National Action Plans and their implementation will need international facilitation and external expertise. Such Action Plans will serve as a basis for mobilizing necessary human, institutional and financial resources. A network consisting of a broad range of partners is needed for SFI to succeed.
- The SFI will increase the benefits from existing programmes. Incremental funding, however, would not be excluded if governments commit themselves to the restoration and management of soil fertility, through the SFI action plan, as an element in an overall strategy for sustainable food security.
- In many African countries, national and international actors are working to enhance food security in the framework of the Special Programme for Food Security (SPFS). The SFI should promote a focus on the actions to restore, maintain and increase soil fertility in ongoing and new programmes, supported by multilateral and bilateral donors, NGOs, national and international agricultural research centres. Close links and coordination with the ongoing SPFS should be established or reinforced.
- National enabling policies and infrastructure are needed to remove market, economic, institutional and legal constraints, in order to provide the farmers with effective opportunities for responsible land management and input use. Supporting government action is thus essential for successful land productivity improvement.
- Where there is a consensus that land husbandry approaches to soil productivity enhancement are appropriate, adjustments are needed in the way in which research is organized, so as to bring specialists and stakeholders, working on the different aspects of soils and land management, together in interactive teams.
- It is also necessary to shift extension away from the prescription of uniform packages to farmers and promote extension methods that help farmers in making their own assessment of constraints and options for improving soil productivity within their particular farming situation, and that encourage

farmer experimentation. This has led to a particular interest in exploring how the farmer field school approach and curricula can be broadened to help farmers cope with the wide-ranging agronomic, technical and economic issues related to soil productivity.

In each of the countries where the SFI process is operational, momentum has been gathering and a number of national experts have been involved in developing the concepts and are keen to pursue them. In most countries, even the modest step-by-step process of the SFI is confronted with funding constraints, although the main donors appear to be supportive in principle.

Support at the political level varies among countries, and will probably not emerge strongly until concrete results are seen on the ground. The greatest danger facing the programme is that this momentum could be quickly lost because of a lack of funds to move forward. There is a need to review, country by country, opportunities to include SFI related activities into ongoing projects and programmes (e.g. extension, research, ASIP, etc.). This review should take place once a consensus is reached on the overall strategy to restore soil fertility.

The UN Convention to Combat Desertification

UNEP and FAO have defined desertification as simply "land degradation in the semi-arid and subhumid zones." However, it was originally defined in terms of a general drying-up of the landscape, associated with both declining rainfall and soil erosion, leading to vegetation changes. The evidence from satellite imagery indicates that the retreat of vegetation is slower than originally claimed, and that the problem of desertification has been overstated. The GLASOD findings show clearly that there is significant soil degradation in these regions.

The objective of the UN Convention to Combat Desertification (UNCCD) is to mitigate the effects of drought in countries experiencing serious drought or desertification, particularly in Africa. Regional, national and local action is to be supported by international cooperation and partnership arrangements, and is to be carried out within the framework of an integrated approach consistent with Agenda 21 of UNCED.

Besides the global mechanism for mobilization of financial resources, the Permanent Secretariat and the Committee on Science and Technology (on which FAO is represented) are already functioning. Through collaboration with other UN agencies (IFAD, UNEP, UNDP, GEF), FAO is assisting member countries in the formulation and implementation of national action programmes (under UNCCD) as well as the formulation of pilot projects in land resources use, management and conservation (for example in Mali and Cuba).

There are several complementary issues (e.g. diagnosis of constraints, land degradation, remedial measures and appropriate technologies for enhancing productivity) within the framework of SFI-NAP, UNCCD-NAP and SPFS, especially in arid and semi-arid environments. This calls for close coordination and harmonized efforts, particularly at country level.

The Convention to Combat Desertification

Action Programmes: elaboration of national action programmes, subregional action programmes and international cooperation.

Framework for technical and scientific cooperation: information collection, analysis and exchange to ensure systematic observation of land degradation in the affected areas and to assess the processes of drought and desertification – an area of prime interest to FAO in general and AGLL in particular, which deals with transfer, adaptation and development of technology.

Supporting measures: capacity building of all types – an area where FAO has a particular comparative strength.

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