Natural Resources Management and Food Security in Sub- Saharan Africa: The need for Improved Linkages

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ABSTRACT

This paper addresses issues of management of natural resources and food security with particular emphasis on land resources. It is argued that technological packages alone cannot result into meaningful increase in agricultural productivity. There is a need to strengthen linkages among researchers, farmers and extension service in order to bring about effective dissemination of the intended technologies. Concerted efforts are needed on the part of the many actors influencing management and use of land resources. One of the challenges is to reduce the barriers facing agricultural development, which often arise from inadequate policy and coordination among key actors. National and grass root strategies are needed to provide a common framework and plan for sustainable use of land resources by pulling together efforts of various actors.

Key words; Food security, natural resources management, sustainable agriculture

Background

Sub-Saharan Africa consists of 39 countries. The region is characterized by diverse agricultural systems that are typically low input and based on subsistence farming. Shifting cultivation continues to be practiced in some areas in the region and often at the expense of dwindling forest reserves and other natural habitats (Tukahirwa, 1992). Thus, land productivity in SSA continues to remain low. The major cause is not only compounded by the dearth of improved technology but also poor economic and agricultural policies insufficient agricultural services such as extension, credit, input supply and marketing (Cleaver and Schreiber, 1994).

Population in SSA is expected to grow to over 1.1 billion people by the year 2020, but Sub-Saharan Africa can potentially support 1,120 million people at low levels of inputs and 4,608 million at high levels of inputs (Badiane and Delgado, 1995). Despite this gloomy picture, land resources of SSA, if used scientifically are adequate to support acceptable standards of living for the current and future population. Concerted efforts are therefore needed in designing agricultural systems

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that will bring about assurance in food security to be achieved through appropriate and strategic land resources management and reduced environmental degradation.

Food security and sustainable agriculture

Food security is defined as access for all people at all times to enough food for an active and healthy life. Three key ideas underlying this definition are: the adequacy of food availability (effective supply); the adequacy of food access, which is the ability of the individual to acquire sufficient food (effective demand) and the reliability of both. Food insecurity can therefore be a failure due to availability, access, reliability or some combination of these factors. Inherent in this concept of food security is an understanding of food producers and consumers as economic agents. Food availability is a function of the supply of food, which depends inter-alia, on relative input and output prices as well as technological production possibilities (Babu and Quinn, 1994). Food access is concerned with the demand for food, which is a function of several variables including the price of food item in question, the prices of complementary and substitutable items, income levels, demographic variables and tastes or preferences. According to Ehrlich *et al.* (1993), to ensure food security, a food system should be characterized by:

- the capacity to produce, store and import sufficient food to meet basic needs for all population groups;
- maximum autonomy and self determination
- reliability such that seasonal, cyclical and other variations in access to food are minimal and
- sustainability, such that the entire ecological system is protected and improved over time

Any meaningful discussion on food security should necessarily be considered at various levels. For example, food security at the national level does not necessarily mean that every household in the country is food secure. A proportion of the population can be living in absolute or relative poverty amidst others who are food secure. Within a country, the food insecure poor comprises of different sub-groups differentiated by location, occupational patterns, asset ownership, race, ethnicity and age (Wheeler, 1991).

The relationship between national and household food security is one of the most important and difficult issues confronting governments in all countries at all levels of wealth and development. Consuming adequate diet is necessary but not sufficient for maintaining a healthy nutritional status. Meaningful increase in agricultural productivity and incomes in SSA will very much depend on how agricultural productivity is sustained within environmental limits.

The Consultative Group of International Agriculture (1988) argued that sustainable agriculture should involve successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources. In this respect *successful* implies that production systems have to be economically viable and socially acceptable. *Management* includes policy decision, *resources* include inputs and *maintaining the environment* suggests that utilization of natural resources should not threaten the capacity to meet the changing needs.

Traditional production systems do not provide adequate possibilities for intensification. The environmental price of adequate food production is "often" loss of natural vegetation, biological diversity and soil erosion. It is argued that it is primarily population growth and poverty that threaten the possibilities for sustainable agricultural development (Kasseba, 1993). Thus, new production systems that utilize external inputs and are able to sustainably produce surplus need to be developed (Singh, 1996[a]). Only through such systems will it be possible to relieve the pressure on natural resources and ensure sustainable agricultural development (FAO, 1991).

Basic resources for food production

The productivity of land depends on suitability of the land resources such as climate, soil, water, biological diversity, the variety of species and the ecosystems that support them. It once seemed that these natural resources had an unlimited capacity to meet human needs. Only in the recently few decades has it been more widely understood that natural resources must be utilised properly and cared for because there are limits to the carrying capacity in terms of supporting human and animal activities (Norse, 1994).

Suitable land

Only a small proportion (25%) of the earth surface is land. Cultivatable land comprises of a soil layer ranging in thickness from a few centimetres to several meters. Where rain and organic matter are plenty it may take only a few years to build up a thin layer of soil, while in dry or cold areas it can take thousands of years. However, the process of degradation, through misuse or erosion, can be very fast thus causing severe negative impact on the suitability of the land (FAO, 1984).

Soils vary greatly in their fertility and ability to hold water and nutrients needed for successful agriculture. The FAO has been mapping and assessing land resources and agro-climates since early 1960s. In 1996 the FAO warned that of the 25% of World's land, only 11% has soils, which without improvement are suitable for agriculture. The remaining land is too dry, too wet, too shallow, affected by chemical problems or permanently frozen (FAO, 1996).

In another study carried out on 117 developing countries in 1975 it was found that 54 countries could not feed their populations because most of these countries were using low-input methods of food production. It was projected that 19 countries, including some of the poorest, would not be able to feed their populations by the year 2000 (FAO, 1991).

Water resources

Whereas limitations to availability and accessibility to suitable land for agricultural production may be severe, the availability of fresh water is likely to be a limiting factor to provision of food for the existing human population. Ideally, water is a finite resource, with about 1,400 million km^3 on earth circulating through the hydrological cycle. However, nearly all this is salty water. Only one hundredth or 1% is fresh and easily available for human use (FAO, 1996).

Agriculture accounts for 65% of water use, but the demands of industry and urban centres are increasing. In addition, water distribution is not even. Had it been so, there would have been very few problems with respect to water resources. Due to demographic pressure, the amount of water per capita is falling throughout the world. It was estimated that between 1950 and 2000 the amount of water requirements per capita would have fallen by over 75% in SSA (FAO, 1984).

Land resource degradation

Land includes not only the soil resources, but also water, vegetation, landscape and micro-climatic components of an ecosystem. Land degradation refers to a temporary or permanent decline of the productive capacity of land or its potential for environmental management. On the other hand, land improvement is an increase in this productive potential. Some types of land degradation are for all practical purposes, irreversible (FAO, 1991). Examples are severe gullies or badlands and advanced salinisation. Alarming figures on soil erosion have been reported in SSA. According to Brown (1981) the Ethiopian Highlands are believed to loose over 1 billion tons of top soil per. The steep slopes of highlands and mountainous landscapes of eastern and South Eastern Africa are naturally prone to erosion and deliver vast quantities of sediments, about 290 million t/year to the surrounding oceans (Milliman and Meade, 1983).

In the Block Mountains of Tanzania high rates of soil erosion exceeding 200 tons/ha/year have been reported (Temple, 1972; Lundgren, 1980; Kimaro, 2003). The reported figures indicate an alarming situation, which calls for appropriate and strategic measures to rehabilitate the degraded lands for improved land productivity. The practicability of rehabilitating degraded lands depends on the costs relative to the value of output or environmental benefits expected. Where farmers wish to intensify agricultural production on a sustainable basis, it may be necessary to undertake land enhancing or land protecting investments even in non-degraded landscapes.

An assessment by Scherr and Yadav (1996) shows that continued land degradation to the year 2020 will present threats to food security for a large number of poor people, to local economic activities and to important environmental products and services. In SSA, land degradation is linked to food security problems and to inadequate technologies for sustainable agricultural intensification in areas of rapid population increase. Natural resource degradation impinging on food security includes nutrient depletion, salinisation, erosion, deforestation, bush and forest fires and water scarcity (Lal, 1986). There is little in terms of agrochemical pollution in the region due to their relatively low level of use.

Assessment of agricultural sustainability as a framework for food security

The total arable land area of SSA is estimated at 131 million ha and the average per capita land area was 0.26 ha in 1990 which may go down to 0.09 ha by 2025 (Table 1). This value is very near to the critical level of 0.07 ha. Yields of major crops in many countries of the SSA continue to show a declining trend (Table 2). Although there is a potential for irrigation to mitigate the drought, only 5 million ha of land is being irrigated (Blake *et al.*, 1994).

Potential yields of crops (Table 3) can be increased several folds with judicious use of inputs such as fertilizers (inorganic and organic) and improved varieties (Lal, 1993). A major concern in designing sustainable agricultural systems in the region is the management of organic matter and rational use of organic inputs including crop residues.

Table 1: Arable land of Sub-Sahara Africa

Regional	Total arable land in 1990 10^6 ha	Per capita arable land[+]		
		1990	2000 ha	2025
Western Africa	62.0	0.29	0.21	0.10
Easter Africa	37.7	0.25	0.18	0.08
Central Africa	10.8	0.20	0.14	0.07
Southern Africa	20.5	0.29	0.19	0.10
Sub-Saharan Africa	131.0	0.26	0.19	0.09

+Assuming no additional land is brought under cultivation and that population continues to increase at rate of 3.2% /yr.

Source: Lal (1993).

Table 2: Grain yields per hectare in four African countries from 1950 to 1952 and 1983 to 1985

Country	Average Yield 1950-1952	1983-1985 (kgha^{-1})	Change (%)
Nigeria	760	714	-6
Mozambique	620	545	-12
Tanzania	1271	1091	-14
Sudan	780	479	-38

Source: (Brown and Wolf, 1986)

Table 3: Potential yields of crops in Sub-Saharan Africa

Land capability	Levels of inputs	Millet	Sorghum	Maize	Bean	Cassava
		Yield (ton/ha)				
Highly Suitable	Low	0.9	1.1	1.6	0.7	2.0
	High	3.5	4.6	6.4	3.0	12.2
Marginally suitable	Low	0.3	0.4	0.5	0.2	0.3
	High	1.2	1.5	2.1	1.0	4.0

Source: Lal (1995).

If such systems are not carefully designed, degradation of land resources will increase and food insecurity will continue to be a problem in the region. It is known that arable production on tropical soils, especially Acrisols and Ferralsols, under traditional shifting cultivation or intensive farming, can lead to decline in soil fertility due to rapid decrease in soil organic matter (Msanya *et al.*, 1998). Declining trends of productivity caused by continuous cultivation without soil amendments or unbalanced nutrient management have been reported (Mowo, 2000). Low input use under continuous cropping even at low level of productivity can lead to loss of about 10 kg N, 1.8 kg P and 7.1 kg K ha^{-1}year^{-1} (Singh, 1996[b]).

One of the key strategies in designing sustainable agricultural systems in SSA is the management of organic matter and rational use of organic inputs. Maintaining or increasing organic matter is of utmost importance in terms of recycling plant nutrients, minimizing the need for inorganic fertilizers and improving soil physical structure. Sub-Saharan Africa has enormous potential for sustainable fertilisation of the land through application of locally available organic resources such as animal manure. Kimbi *et al.* (2001) estimated animal manure output in Tanzania and observed that available manure for agricultural use is about 14 million metric tons per year.

Table 4 gives estimated manure output in selected districts in Tanzania. Assuming that average total N content of the manure is 0.7%, the total N from the annual manure supply is about 98,000 tons. This could sufficiently fertilise significant proportion of arable land in Tanzania (about 7000 hectares at conservative estimates). Irrespective of this potential, very few farmers are using this resource for agricultural production. The situation is similar in other SSA countries.

Table 4: Estimated livestock population and manure output (metric tons) per year in selected districts in Tanzania

District	No. of cattle	Cattle manure output[1]	No. of goats	Goats manure output[2]	No. of sheep	Sheep manure output[3]
Morogoro Rural	5348	169177	2021	61897	274	14779
Kilosa	29509	40378	139245	101649	34893	25472
Dodoma Rural	478012	654262	220600	161038	78889	57789
Kongwa	114896	157255	129900	94827	33704	24604
Moshi Rural	128771	242679	122172	89186	54879	40062
Same	170020	232687	106597	778158	123088	89854

[1] = Based on yield of 5kg of manure per cow per day
[2] = Based on yield of 2kg of manure per goat per day [3] = Based on yield of 2kg of manure per sheep per day Cattle Growth per year = 2.3%, Goats = 3.26% Sheep = 0.11%

Source: Kimbi et al (2001)

Mugwira and Mukurumbira (1984) observed that irrespective of the availability of different types of animal manure in the communal areas of Zimbabwe most small scale farmers do not take advantage of such resources. Bekunda and Woomer (1996) evaluated banana-based cropping systems of the Lake Victoria basin in Uganda. They concluded that such a cropping system was sustainable due to re-cycling and management of various organic resources available in the basin. Rapid loss of organic matter of the topsoil under continuous cultivation is a common phenomenon in SSA. Singh and Goma (1995) found that the level of topsoil organic matter at Kasama, Zambia declined throughout the 25 years of research period. This was particularly the case where there was continuous cultivation with inadequate replenishment of organic matter. Results of long-term assessment of land productivity in Tanzania and Zambia compiled by Aune (1996) indicate that the average annual yield decline was about 8% in low input systems and about 3% in high input systems (Table 5). These results suggest that soils of these areas are not able to sustain productivity under continuous cultivation without sufficient inputs.

Table 5: Annual changes in productivity under low and high input systems

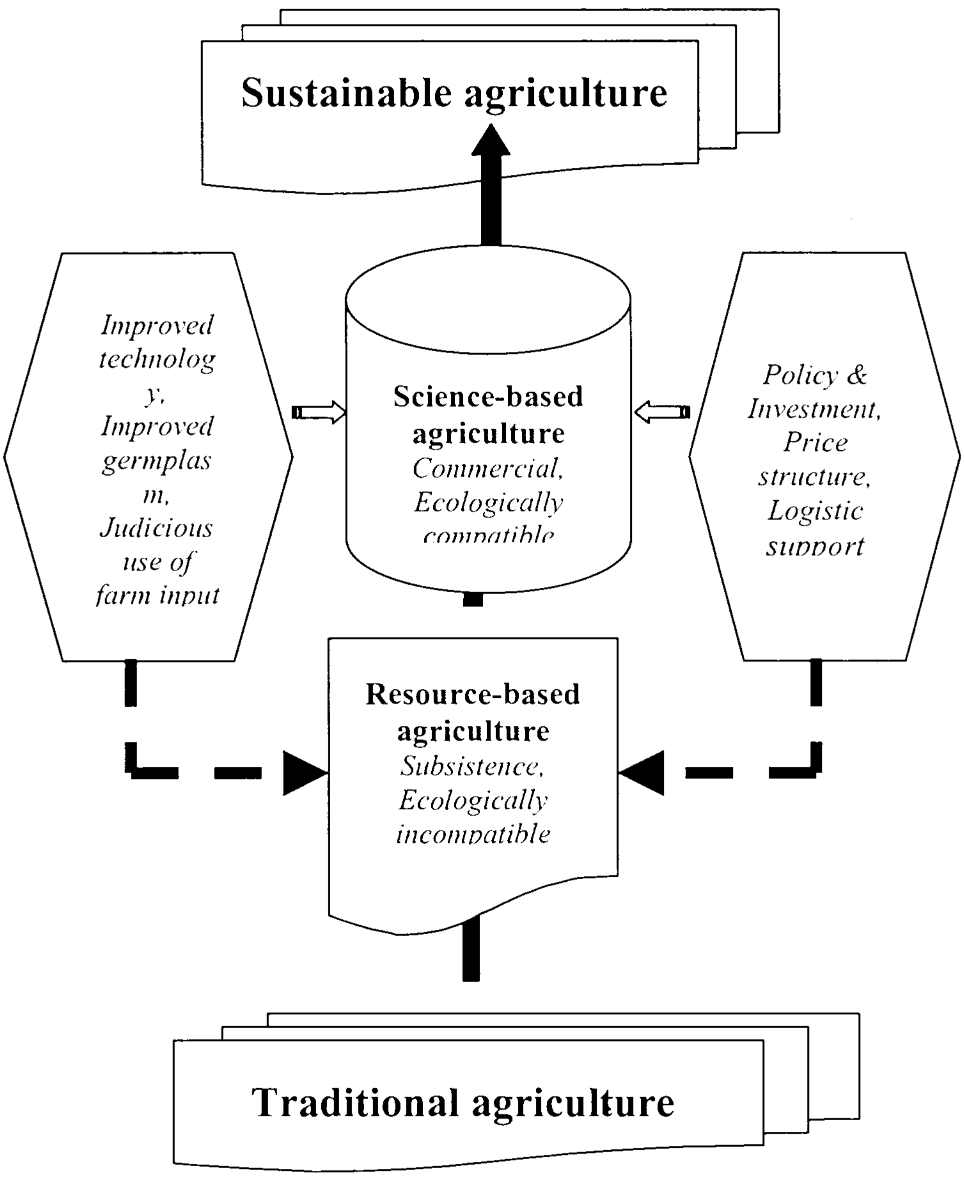
Location	Crops	Experimental duration	Annual changes in production (%) Low input	High input
Mwala (T)	Maize	9	-19.7	-3.4
Mwala (T)	Groundnut	9	-10.3	+4.7
Uyole (T)	Maize	11	- 9.5	+3.9
Kazama (Z)	Maize	17	-7.8	-11.5
Kasama (Z)	Groundnut	10	-18.6	+0.6
Magoye (Z)	Maize	15	-1.3	-3.2

T: = Tanzania, Z: = Zambia

Source: Aune (1996)

Technological options and potential prospects

Land resources of SSA are being over-stressed. Sustainability of any production system requires proper balance in the input/output of resources (Singh and Vaaje, 1996). A wide array of technological options is available for enhancing agricultural sustainability and attaining ecological balance. Lal (1993), for example, presented an overview of various options for sustainable agriculture in different ecological regions of SSA. The issues addressed include how to balance the inputs required, maximising efficiency and costing effectiveness of inputs, reducing risk of soil and environmental degradation, maximising per capita productivity and sustaining an increasing trend in productivity. The present declining trends of land resources and productivity may dictate a shift from resource-based to science-based technologies which ensure better control of the crop requirement, selection of crops and cultivars adapted to agro-ecological conditions, soil fertility enhancement/maintenance and prudent use of inorganic fertilizers, biological/integrated pest management and better water management systems as depicted in Figure 1.



BNF = Biological Nitrogen Fixation, IPM = Integrated Pest Management

Source: Modified from Lal (1986)

Figure 1: Management systems that reconcile with agricultural sustainability and environmental quality

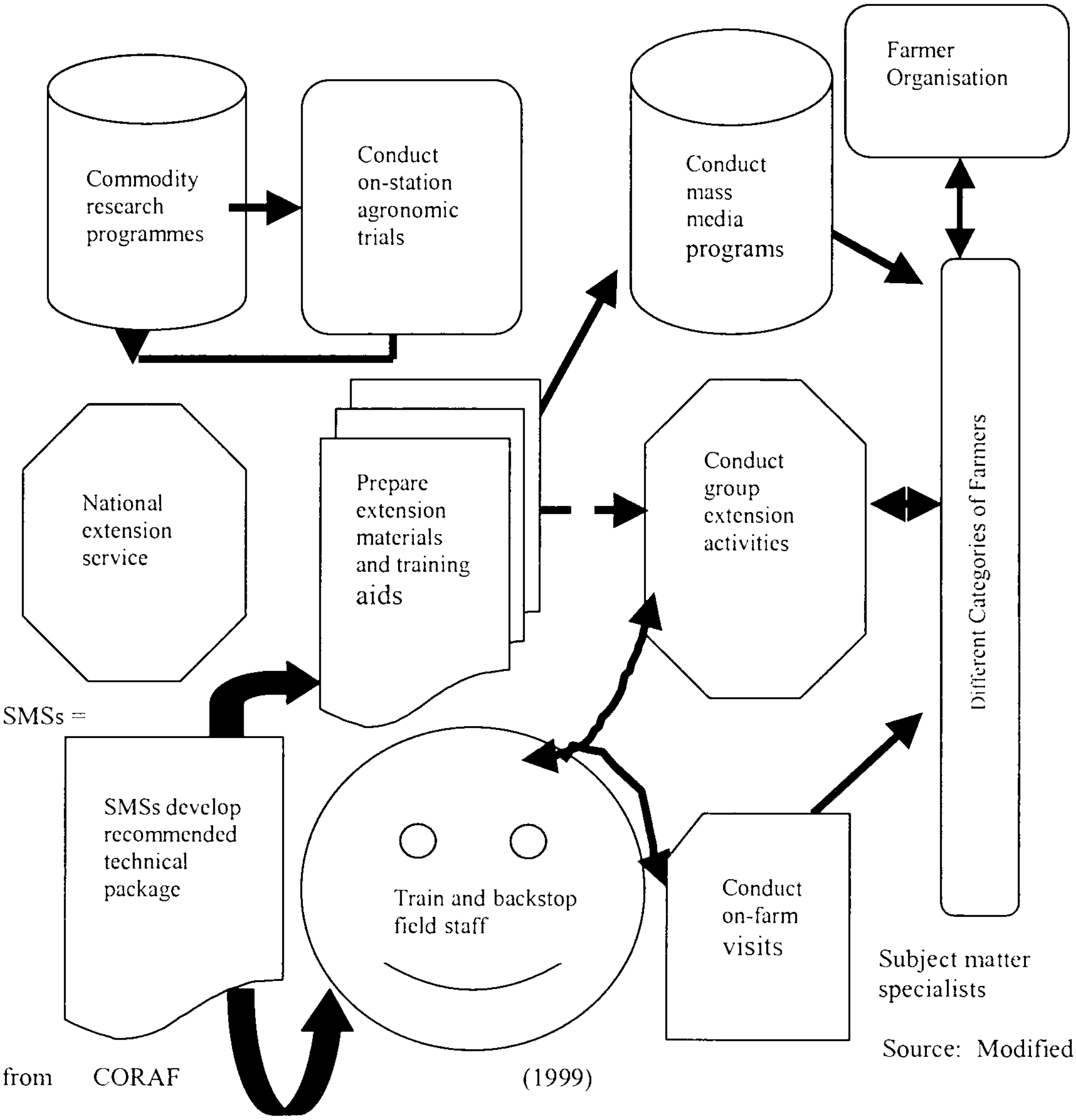
According to Fernandes and Matos (1995) most resource poor farmers in the SSA cannot have easy access to resources such as inorganic fertilizers and other chemical inputs. Crop and agro-forestry systems must therefore have as many characteristics as follows:

- Biological and structural diversity to reduce biophysical and economic risk
- A high degree of soil cover via plant canopies or plant residues incorporated in the soil and properly managed
- High value but low biomass of products to reduce nutrient exports
- The return of crop residues and animal manure to the cropped land to maximize nutrient recycling
- The use and optimum management of improved crop varieties and animal species
- Where possible, the application of adequate levels of organic and/or inorganic fertilizer sources to balance nutrients removal in harvests

Need for improved linkages among researchers, farmers and extension

Adequate levels of agricultural productivity cannot be achieved by technological packages alone. Many improved technologies, although technically sound, may not reach the ultimate users due to various other constraints, including weak institutional linkages Even with reduction in population growth rates and careful management of the natural resource base, agricultural productivity will continue to decline unless there are deliberate efforts to strengthen the linkages involved in generation and dissemination of agricultural technologies (Merrill-Sands, 1992). A linkage between research and extension, and with different categories of farmers and farmers' organisations is one of the most difficult institutional problems confronting most countries in SSA. The term ''linkage'' in this context includes diverse forms of collaboration among research systems, farmers and extension service.

Institutional research and extension in SSA has had little success in generating and disseminating agricultural technologies which are widely adopted by small scale resource disadvantaged farmers (CORAF, 1999). Farmers play a pivotal role in the process of technology generation, dissemination and adoption. Figure 2 shows an example of agricultural extension system depicting farmer linkages through organizational mechanisms. There is an urgent need for strengthening agricultural research and technology dissemination and support systems in order to increase agricultural productivity, reduce poverty and increase economic growth. Agricultural research and extension need to aim at increasing productivity and production through effective expansive diffusion of knowledge and information. Stronger linkages ensure that research agenda is based on farmers' priority problems and that technologies generated by researchers are effectively disseminated to the intended users. Useful technologies generated by researchers should effectively reach farmers. Meanwhile, effective linkages depend on a minimum number of conditions such as research policies that are oriented towards development needs, whereby researchers learn from farmers' experience and strengthening of collaboration networks among them (Swanson, 1993). Building linkages implies a reciprocal recognition and clear vision of responsibilities of each of the key stakeholder.



SMSs = Subject matter specialists

Source: Modified from CORAF (1999)

Figure 2 Relationship between agricultural extension system and farmer linkages through organisational mechanisms

Conclusions and recommendations

Sustainable and effective management of natural resources for enhanced food security call for integrated policy initiatives. The issue of sustainability in food security within acceptable environmental limits is a complex one and hence the purpose of this paper was not to propose solutions to pertinent questions pertaining to sustainable agricultural production systems. Focus was rather placed on key land resources aspects, which have a direct bearing on food security in SSA. The declining trends in management of land resources and productivity may dictate a shift from resource-based to science-based technologies which among other things ensure better control of the environment in terms of integration of bio-physical and socio-economic factors.
In view of the above, the following key policy recommendations are pertinent:

- Increase research and technology development associated with effective dissemination system by strengthening research- farmer- extension linkages
- Increase awareness of land degradation and develop appropriate land management programmes
- Support grass root level organizations to manage local resources. A more people-centred approach is likely to be more effective.
- Develop conducive marketing conditions. Poorly developed markets are major constraints to widespread adoption of land-improving practices.
- Encourage rural income growth and diversification. General income growth and diversification can substantially help in reducing land degradation and promote land improvement through several mechanisms such as crop-livestock systems and crop rotation.

References

Aune J. B. (1996). Soil degradation in Tanzania and Zambia: Evidence, model predictions and policy implications. *Ecology and Development.* Paper No. 19. NORAGRIC, Agricultural University of Norway.

Babu, S. C. and V. Quinn (1994). Food security and nutrition monitoring in Africa. *Food Policy* 19(3):211-217.

Badiane, O. & C. L. Delgado (1995). A 2020 vision for food, agriculture and environment in Sub-Saharan Africa. Food, agriculture and the environment. Discussion paper No. 4. International Food Policy Research Institute. Washington D.C.

Bekunda, M. A and P. L. Woomer (1996). Organic resource management in banana based cropping systems of the Lake Victoria basin, Uganda. *Agricultural Ecosystems Environment*. 59:171-180.

Blake, R. O; J. Mathews and R. S. McNamara (1994). Feeding ten billion people in 2050: *Key role of international agricultural centres.* World Resource Institute, Washington, D.C.

Brown, J and E. Wolf (1986). Assessing ecological decline. In Starke, L. (Ed.) State of the world. Norton and Company, New York.

Brown, L.R. (1981). Eroding the base of civilisation. *Journal of Soil and Water Conservation*. 36: 255-260.

Cleaver, K. and G. A. Schreiber (1994). *Revising the spiral, the population, agriculture and environment nexus in Sub- Saharan Africa*. Word Bank, Washington, DC.

Consultative Group on International Agricultural Research/Technical Advisory Committee (1988). *Sustainable Agricultural Production: Implications for international agricultural research*. Adv. Comm. Secretariat, FAO, Rome.

CORAF (1999). Strengthening research, extension, farmers' organisation linkages in West and Central Africa: An overview paper. ODI, UK.

Ehrlich, P and A. Ehrlichand (1993). "Food security, population and environment." *Population and Development Review* 19(1): 1-32.

FAO (1996). *Production yearbook*. FAO, Rome.

FAO (1991). *Production yearbook*. FAO, Rome.

FAO (1984). *Land, food and people*. FAO, Rome

Fernandes, E. C. and J. Matos (1995) Agroforestry strategies for alleviating soil chemical constraints to food and fibre production in Brazilian Amazon. *American Chemical Society Symposium Series* No. 588. ACS Books Department Washington, DC.

Kasseba, A.M. (1993). Strategies for developing a viable and sustainable agricultural sector in Sub-Saharan Africa. *In* J. Ragland and R. Lal (eds) Technologies for sustainable agriculture in the tropics.p.211-244.ASA Special Publication. No.6. ASA, Madison, Wisconsin, USA.

Kimaro, D.N. (2003). Assessment of major forms of soil erosion in the Morningside Catchment, Uluguru Mountains, Tanzania. PhD Thesis submitted for examination, Sokoine University of Agriculture. pp 258.

Kimbi, G., G., J. Semoka, and J. Lyimo-Macha (2001). Management and Utilization of Animal Manure as a Resource for Crop Production in two grazing systems in Tanzania .*Tanzanian Journal of population studies and development.* 2(4) 17-31.

Lal, R. (1986). Soil surface management in the tropics for intensive land use and sustainable production. *Advanced Soil Science* 5:1-110.

Lal, R. (1993). Technological options towards sustainable agriculture for different ecological regions of Sub-Saharan Africa. *In*: J. Ragland and R. Lal (eds) Technologies for sustainable agriculture in the tropics.p.295-308.ASA Special Publication. No.6.ASA, Madison, Wisconsin, USA.

Lal, R. 1995. Erosion-crop productivity relationships for soils in Agriculture. *Soil Science Society. American Journal.* 59:661-667.

Lundgren, L. (1980). Comparison of surface runoff and soil loss from runoff plots in forest and small-scale agriculture in the west of Usambara Mountains, Tanzania. *Geografiska Annalar* 62: 113-178.

Merrill-Sands, D. (1992). Managing links with technology users: A training module. The Hague: International Service for National Agricultural Research.

Milliman, J.D. and R.H Meade. (1983). World-wide delivery of river sediment to the oceans. *Journal of Geology*, 91, 751-762.

Mowo, J.G. (2000). Effectiveness of phosphate rock on Ferralsols in Tanzania and the influence of within-field variability. PhD thesis, Department of Environmental Science, Sub-department of Soil Science and Plant Nutrition, Wageningen University. pp 164.

Msanya, B.M., Kimaro, D.N. and Araki, S. (1998). Characteristics of two pedons and their implication for environmental management in part of Mbinga District, Tanzania. *Tanzania Journal of Agricultural Sciences, Volume* 1 (64-70).

Mugwira, L. M. and L. M. Mukumbira (1984). Comparative effectiveness of manures from the communal areas and commercial feedlots as plant nutrient sources. *Zimbabwe Agricultural Journal.* 81:241-250.

Norse, D. (1994). Multiple threats to regional food production: Environment, economy, Population? *Food policy* 19(2): 133-148.

Scherr, S. A. and S. Yadav (1996). Land degradation in the developing countries: Implications for food, agriculture and the environment to 2020. Discussion paper No. 14. International Food Policy Research Institute.

Singh B. R. (1996[a]). Sustainable Agriculture in Sub-Saharan Africa: How sustainable is it? *In* Kimbi, G. and S. Mugo (Eds.) Sustainable Development in Sub-Saharan Africa. Cornell University, NY. USA.

Singh, B.R. and P. Vaaje (1996[b]). Sustainable management of nitrogen in east Africa. In: Structural adjustment policies and environmental degradation in Tanzania, Zambia and Ethiopia. Ecology and Development paper 19, NORAGRIC, Agricultural University of Norway, Aas, Norway.

Singh, B. R. and H. C. Goma (1995). Long-term soil fertility experiments in eastern Africa. In Lal, R and B. A. Stewart (eds) Soil Management-Experimental Basis for Sustainability and Environmental Quality.p.347-382. Lewis Publishers, Boca Raton.

Swanson, B. (1993). Identifying linkage problems using systems analysis: A training module. Urbana, IL. USA.

Tukahirwa, E. M. (1992). Environmental and natural resource management policy and law: Issues and options: II. Documentation. Makerere University. Institute of Environment and Natural. Resources. Kampala, Uganda.

Temple, P.H. (1972). Soil and water conservation policies in the Uluguru Mountains, Tanzania. *Geografiska Annalar* 54A(3-4), 110-123.

Wheeller, E. F.(1991). Intra-household food and nutrient allocation. *Nutrient Reviews* 4: 69-81.