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LAND USE CHANGES, IMPACTS AND OPTIONS FOR SUSTAINING PRODUCTIVITY AND LIVELIHOODS IN THE BASIN OF LAKE VICTORIA

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ABSTRACT.

Land-use change is one of the main drivers of environmental change. It influences the basic resources of land, including the soil. Its impact on soil often occurs so creepingly that land managers hardly contemplate initiating ameliorative or counterbalance measures. Poor land management has degraded vast amounts of land, reduced our ability to produce enough food, and is a major threat to rural livelihoods in many developing countries. Land use in the basin of lake Victoria like other parts of east Africa is changing fast. While some areas are undergoing expansion of cultivation and grazing, others are intensifying. Common to all is that there are impacts on sustainability of the natural systems on which productivity depends. The nature of landscapes and the geomorphologic processes in the lake basin make land use change highly sensitive to erosion and degradation. There is an urgent need for a regional framework and guidelines for sustainable land management including all sectors of land use like cropping, grazing and urbanization. This paper highlights some of the changes in land use in the lake basin, presents the implications of these changes on productivity and gives some investment options for developing sustainable land use.

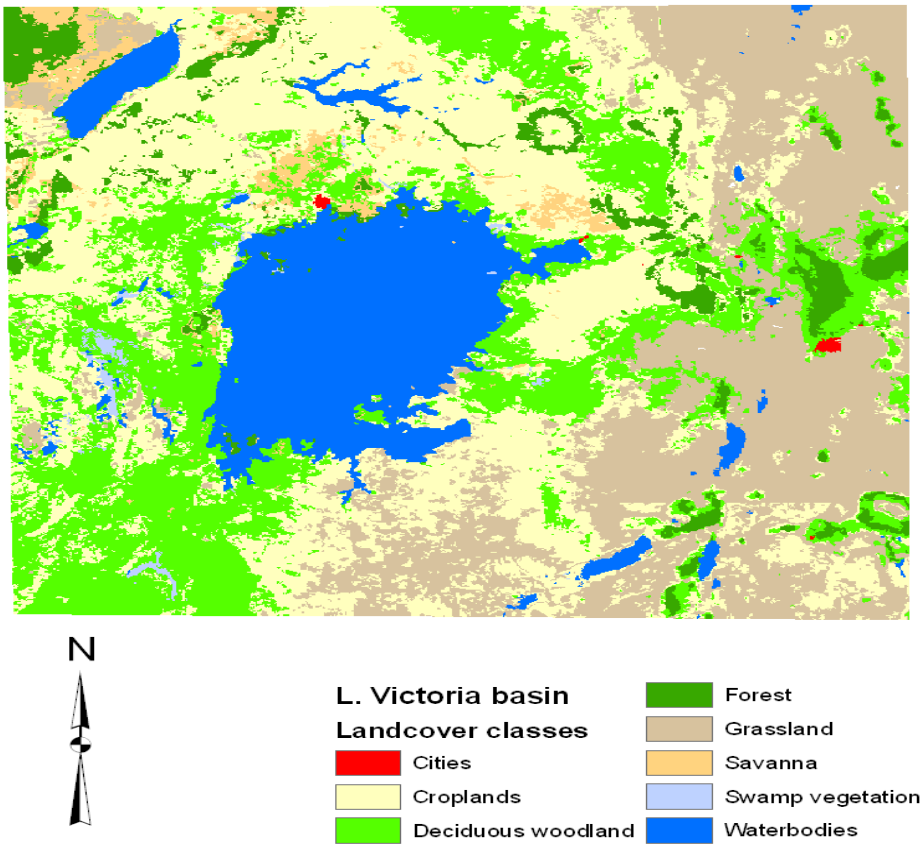
Key words: Land use / cover change, sustainable development, Lake Victoria basin, land management, land degradation.

INTRODUCTION

The basin of lake Victoria (Fig.1) is endowed with abundant natural resources, which provide livelihoods for rural people in three countries (Kenya, Uganda and Tanzania), and contribute significantly to the respective national economies either through direct sales of its resources like fish or by playing a role in food security. In addition to fish, the lake basin plays a big role in agricultural production through cultivation of various subsistence and cash crops. The area is a drainage basin for a big part of east Africa, ranging from Mt. Elgon at the border of Kenya with Uganda, to the Mau summit, and the Ruwenzori ranges in south west Uganda. Lake Victoria is the head waters of river Nile that is a long ribbon of life for many millions of people in Sudan and Egypt.

The basin covers an area of 184,200 km^2 comprised of 11 rivers and a large lakeshore area that supports a very dense rural populations totaling to about 28 million people (Hoekstra and Corbett, 1995). About 21 million people in the Lake Victoria Basin (estimated from data by Deichmann, 1994) rely primarily on subsistence agricultural and pastoral production for their livelihoods. Poverty levels are high and agricultural production is low. The region has one of the poorest areas of Kenya and Tanzania, where the percentage of the population living below the poverty line – i.e. on less than a dollar a day – is 61 % and 41 % respectively, compared to the national average for the two countries of 52 % and 36 % (Hoekstra and Corbett, 1995). In Uganda, the region contains several districts where the percentage of people living in absolute poverty is far lower than the national average of 39 %. In sum, the Lake Victoria Basin is a region marked by negative trends in terms of living conditions, the environment and natural resources.

Fig 1. Land Use Changes in the Lake Basin



From ICRAF 2004

Agriculture – mainly the cultivation of maize, rice, sugar, coffee, tea, cotton and horticultural products – and livestock rearing employ some 75 % of the workforce in the region and form the basis of its economic viability. The area was formerly rich in natural forests but this resource has been severely over-exploited (Swedish Report

2006). Deforestation combined with unsustainable agricultural methods has resulted in widespread, increasingly conspicuous land degradation. Agro industries based on sugar, cotton and tea in the upper parts of the basin predominate. The sugar and textile industries are exposed to stiff competition from import businesses and enterprises in other parts of Kenya and Tanzania, and a number of companies have gone out of business as a result. Light industry and handicraft enterprises, often operating in the informal sector, are also important contributors to the region's productive wealth.

The patterns of land use in the lake basin are highly determined by rainfall amounts and soil characteristics. The eastern part of the lake basin is drier and characterised by short bushy vegetation with scattered trees. Forests are limited to hill tops, river catchments and some seasonal flood plains. Land use is generally cultivation of subsistence food crops like sorghum, and maize with root crops like cassava and groundnuts. A number of areas are uncultivated and remain as communal grazing areas especially around hills and escapement slopes but the number and the extent of these patches are becoming smaller and smaller over time. The wetter western side is more intensively cultivated with more perennial crops like bananas and coffee in small scale farms.

This paper discusses land use changes and problems caused based on two case studies 1) Sango Bay in Uganda 2) Lambwe Valley in Kenya, and draws from lessons learnt in other areas of east Africa on the subject of land use change, causes impacts and implication on sustainable development.

Sango Bay

LUCID (Land Use Change Impacts and Dynamics) project has conducted land use change analysis in Sango Bay, Uganda along with several other areas in east Africa to assess the changes, the root causes of the changes and to document the impacts of such changes. Unlike most other areas of east Africa Sango Bay reported little changes in land use between 1955 and 2000. However, Sango Bay is an important biodiversity area because of its rich and diverse forests and wetlands. Subsistence farming is the main economic activity and it employs over 80% of the population in the area. Livestock rearing is the second most important economic activity in the area.

Results of land cover/use change analysis for Sango Bay are presented in Table 1. Between 1955 and 1985 only 33 km^2 (1.3%) of the total terrain was converted to subsistence farming. Secondly, between 1955 and 2000, 48 km^2 (2.0%) of the total terrain had been converted to subsistence farming. Only 15km^2 (0.6%) of the total terrain was converted to subsistence farming between 1985 and 2000.

Land Cover/use category	Land cover extent (km^2)			Change (km^2)		Change (%)	
	1955	***1985***	***2000***	***1955-1985***	***1955-2000***	***1955-1985***	***1955-2000***
Tropical rain forests	268.3	264.6	263.0	-3.7	-5.3	-1.4	-2.0
Savannah	673.1	646.8	636.8	-26.3	-36.3	-4.0	-5.4
Wetlands	321.3	317.8	316.2	-3.5	-5.1	-1.1	-1.6
Short grass/bare	67.7	67.7	66.1	0.0	-1.6	0.0	-2.4
Subsistence farming	1110.6	1143.6	1158.7	33	48.1	3.0	4.3
Large scale farming	0.4	0.4	0.4	0.0	0.0	0.0	0.0
Water	9.3	9.3	9.3	0.0	0.0	0.0	0.0
Total cover	2450.7	2450.2	2450.5				

Table 1. Sango Bay: Land cover/use changes between 1955 and 1985, and 1955 and 2000. Mugisha 2002.

These observations led Mugisha, 2002 to conclude that there was insignificant land use extensification in Sango Bay between 1955 and 2000. However, based on socio-economic surveys, it appears that there is significant land use intensification, especially grazing. The LUCID Project conducted a survey on the problems of land use in Sango bay as perceived by the local communities and developed a ranking based on the order of importance as: 1) over population, 2) poverty, 3) early marriages, 4) loss of soil fertility. 5) Limited market accessibility, 6) invasions by plant diseases and pests, and 7) pollution by agricultural chemicals.

Lambwe Valley, Kenya

Several attempts have been made to show changes in land-use in Lambwe valley during the last 20 years in which there has been a significant increase in human settlements. One of these efforts was a reconstruction of a land use map of 1972 based on information from local communities. Members of the community, who in 1992 were about 57 years old and could recall the landscape characteristics some 20 years earlier, were invited to draw on the ground the outlook of their surroundings as they could recollect their memories on a village to village level. The map generated by this community exercise shows that prior to 1972, most of the valley floor was neither cultivated nor settled by people, except for a few settlements around shopping centres, and along access roads.

According to demographic statistics by the Office of Vice President and Ministry of Planning and National Development (1994 - 1996 Homa Bay District Development Plan) population in Gwassi division that comprises of Lambwe Valley, increased from 23,402 in 1979 to an about 39,259 in 1996. This indicates a population increase of

68% over a period of seven years. This increase in population is attributed to migrations from surrounding areas outside the valley district.

Land Use patterns show the higher elevations are primarily used for grazing, while the Valley floor is mainly used for cultivation except in places that are usually flooded during rainy seasons. Land Use in Lambwe Valley shows a generalised pattern of land use as can be seen across the valley. Altitudinal distribution of homesteads appears to separate the cultivation fields down the valley and grazing fields at higher elevations up the hills. Although tsetse infestation may have been the main reason for higher elevation settlements, flooding may also have contributed to keeping people away from the valley floor especially when land was still available at higher elevations. Currently there is a rapid encroachment of cultivations down the valley floor in the areas that were generally avoided due to tsetse infestation. Although tsetse control may not be the only factor responsible for the valley floor settlements, it is quite clear that the inherent fear of trypanosomosis infection no longer exist (Ssennyonga, 1997).

Effects of climate change on land use

Results now available form climate and land use interactions research project (CLIP) conducted by Michigan State University and the International Livestock Research Institute (ILRI) indicate a warmer and drier basin of Lake Victoria. The will have adverse effects on all land based productive systems in the basin. The changes are likely to cause big challenges on efforts to alleviate poverty and promote food security. It is therefore necessary to consider interventions to prepare the communities on how to adapt to climate change.

Trends and implications of changes in land use and land cover

Conversion of land use

Land cover is defined by the attributes of the earth's land surface and immediate sub surface, including biota, soil topography, surface and ground water and human structures as in the case for agricultural expansion or deforestation (Lambin, Geist, Lepers, 2003).

The largest conversion of land use in east Africa over the last 50 years has been the expansion of agriculture at the expense of grazing land. Prior to 1950, semi-arid and sub-humid areas were predominantly pastoral with scattered settlement and cultivation. From the 1950s to the present there has been significant transformation of grazing land to mixed crop-livestock agriculture.

The rate of agricultural expansion appears to be slowing down in several areas (e.g., below Mt. Kilimanjaro on both the Kenyan and Tanzanian sides and on the eastern slopes of Mt. Kenya). The slowing is occurring especially where the conversion frontier is in drought-prone land. The rate of rural population growth is also slowing in many places (Campbell, Lusch, Smucker and Wangui, 003; Olson, Butt, Atieno, Maitima, Smucker, Muchugu, Murimi, and Hong

Xu, 2003). In other areas (e.g., Ugandan sites) the expansion of agriculture is continuing at a rapid pace (Mugisha 2002, Tukahirwa, 2002)

Communal land resources including grazing, fuel wood and medicinal herbs disappear, a loss that often affects the poor the most. As land is converted, the patchwork of cultivation and natural vegetation gives way to private, cultivated farmland (Maitima, Reid, Gachimbi, Majule, Lyaruu, Pomeroy, Mugatha, Mathai, Mugisha, 2004); Olson, Misana, Campbell, Mbonile, and Mugisha, 2004(a). Methods of maintaining soil productivity such as shifting cultivation and long term fallowing, are no longer practiced. Erosion and declines in soil organic carbon and soil nutrients are often severe.

***Issues* in systems undergoing extensification and moving towards continuous cropping**

These include:

a) Fuel wood collection is impacting watersheds and other natural resources. Trees are cut for curing of tea in upper zones and to sell as charcoal to cities in lower zones (Olson, Misana, Campbell, Mbonile and Mugisha, 2004(a).
b) Loss of communal pasture, woodlands and other natural areas for grazing or to collect native plant and animal species (Maitima, Reid, Gachimbi, Majule, Lyaruu, Pomeroy, Mugatha, Mathai and Mugisha 2004; Olson, Misana, Campbell, Mbonile and Mugisha, 2004(b).
c) Land use change from bush to grazing tends to reduce organic carbon content, soil moisture, pH, bulk density and nitrogen. This does not affect forage productivity until grazing intensity reaches a certain level (Kamau, 2004).
d) Land use change from grazing to continuous cropping rapidly impacts soil properties. Former methods to maintain soil productivity such as shifting cultivation and fallowing are no longer practiced. Erosion, leaching and removal of vegetation can be significant. Soil organic carbon (SOC) and the nutrients potassium (K) and phosphorous (P) are the most affected (Maitima, Reid, Gachimbi, Majule, Lyaruu, Pomeroy, Mugatha, Mathai, Mugisha, 2004).
e) Livestock raising tends to evolve towards: smaller herd sizes per family; fewer cattle and proportionately more goats and sheep; grazing is done near the homestead or animals are tethered; and at least in Kajiado, women are taking on more of the animal care (Campbell, Lusch, Smucker and Wangui, 2003).

Land cover modifications Intensification

Land cover modifications are more subtle changes that affect the character of the land cover without changing its overall classification as is usually found in agricultural intensification.

Intensified systems are in rapid flux

Intensification process is often due to farmers' response to reducing land sizes, changes in commodity prices and markets, labour availability, and governmental policies such as parastatal support. This has led to the rise, decline and sometimes rise again of export crops. On the other hand, farmers are moving to fulfil a growing demand in national urban markets for higher-end, easy to prepare food such as livestock products (meat, dairy, and eggs), rice, bananas and other fruit, vegetables and potatoes. This is leading to an expansion of these products to new zones, such as dairy expanding to semi-arid areas and bananas to former coffee zones.

Issues in intensifying systems

These include:

a. *Low and declining soil productivity* in many fields.
b. *Land management and soil productivity vary widely* between areas and households. Poorer households with few animals and small farms make fewer investments and tend to have more soil degradation. Gender disparities and HIV-AIDS reinforce the situation of poverty. Areas with low-value crops, far from the market, or unreliable rainfall invest less in soil management. On the other hand, soil productivity is improving on farms and in areas that invest in the land.
c. *Small and declining farm sizes*. Some families are near-landless in all zones.
d. *The systems are in constant flux* with changing commodity markets and prices. Many farmers are switching from export crops to supplying urban markets for livestock and crop products.
e. *Governmental policy and programmes* also frequently changed. Those affecting land management have included changing access to credit, price incentives, subsidies for fertilizers and pesticides, import policies, the strength of extension services, decentralisation and centralisation of land management, and changes in land tenure arrangements.
f. *Little community level land use planning* to optimise land resources: water, grazing, woodlands, soil and water conservation, etc.

The decline in soil productivity

Poor soil productivity is common in all the areas of the basin covered by the three countries but most dramatic in Kenya and Tanzania where nutrient levels (SOC, P and K) have sunk to very low levels since the 1980's. The reasons for this depletion are related to land use and management changes, and were probably made worse by the removal of fertilizer subsidies in the 1980s. Rates of nutrient depletion also vary according to soil properties, with the sandy soils in Kenya sustaining higher losses than the predominantly clayey soils in other sites (Maitima, Reid, Gachimbi, Majule, Lyaruu, Pomeroy, Mugatha, Mathaia nd Mugisha, 2004).

Changes in soil and Land management

Farmers respond to changes in soil productivity in various ways including: 1) installation of soil erosion control techniques; 2) application of manure; 3) purchase of chemical fertilizers and pesticides, and 4) planting of trees and fodder grasses. In general, those crops that are marketed and are of high value receive the most inputs, and those zones with the strongest market links apply the most inputs.The techniques require substantial labour and cash investment by farmers, and often involved agricultural extension support. Government, parastatal or NGO programmes were particularly influential in organizing erosion control, encouraging mulching, and supplying chemical inputs.

In situations when programmes stopped, such as due to civil unrest in Uganda, the collapse of parastatals in Kenya or structural adjustment in Tanzania, farmers have often ended practices. Chemical inputs that had been widely used were abandoned or their use confined to selected, marketed crops. Terraces were maintained in Southwest Uganda but became boundary markers rather than for erosion control. However, the application of manure and the planting of trees and fodder plants have continued perhaps because they require less capital and provide clearly realized benefits [Tukahirwa, 2002; Olson, Butt, Atieno, Maitima, Smucker, Muchugu, Murimi and Hong Xu 2003; Mbonile, Misana, and Sokoni, 2003; Misana, Majule, and Lyaruu, 2003; Olson, Misana, Campbell, Mbonile and Mugisha,2004(a)].

Impact of management on productivity

The amount of SOC in the higher elevation zones in Kenya is adequate in agronomic terms but inadequate in other sites in Kenya, Tanzania and Uganda. In the upper zones of Kenya, the soil type, moderate temperatures and available moisture allow slow decomposition. Carbon levels are highest under coffee, bananas, woodlots and pasture due to management practices. In similar land uses in the middle and lower zones, environmental factors favour rapid decomposition and SOC was lower. In the lower slopes of Mount Kilimanjaro in Tanzania, however, there is a marked regeneration of soil organic carbon under pasture and maize/beans due to the application of animal manure and crop residues, mulching, and terracing. The impact of soil management is similarly evident in Kenya. Farmers report in field questionnaires that soil productivity is increasing in 49% of fields in Embu, 48% in Mbeere, but only in 17% of fields in Kajiado. Productivity has declined, however, in 37% of fields in Embu, 44% in Mbeere, and 54% in Kajiado, levels that correspond with intensity of soil management. Most often, farmers credit the application of manure for productivity increases and blame the lack of manure for decreases (Campbell, Lusch, Smucker and Wangui 003; Olson, Butt, Atieno, Maitima, Smucker, Muchugu, Murimi and Hong Xu 2003; Maitima, Reid, Gachimbi, Majule, Lyaruu, Pomeroy, Mugatha, Mathai Mugisha 2004).

Who invests in soil management?

The rapid response to the changing economic and policy context, however, does not imply that all farmers are gaining wealth or are capable of investing in new commodities or soil management. Even in the most intensive zones, the variation between households in levels of soil productivity is significant. A common pattern emerged of how the lack of household resources impacts soil management, particularly the application of manure and chemical inputs. Poorer households make significantly fewer investments due to a combination of lack of animals, small farm sizes, and lack of labour and low non-farm income.

The variability in soil management is closely related to the number of adults in the household and the gender of the acting head of household. The poorest households investing the least on the land tend to be women headed. The absence of the husband from the farm is closely associated with poverty. Husbands leave small farms to seek work because the family needs non-farm income, but once the husband has left, farm sizes or other indicators of wealth usually do not improve. Gender disparities and HIV-AIDS reinforce the already precarious situation of poverty [Olson, Butt, Atieno, Maitima, Smucker, Muchugu, Murimi and Hong Xu 2003, Mbonile, Misana, and Sokoni 2003; Olson, Misana, Campbell, Mbonile and Mugisha, 2004(a)].

CONSEQUENCES

Conversion of primary land cover to cultivation replaces natural vegetation cover with crops either planted as mixed cropping or planted and maintained as monoculture. In addition to planting food-crops there are fields planted with pastures for livestock grazing, woodlots for shade and fencing and homesteads. Within the cropped areas there are many types of crops planted and each type could have different management practices and therefore will affect the land differently.

Changes in land use are here reported to reduce plant species numbers and percentage cover for all vegetation categories and all land use types. Land use in monocultural cropping system results to more loss on species numbers than mixed cropping system.

Land use change causes habitat fragmentation thereby reducing habitat for wildlife. This has created restrictions on wildlife movements and their access to key resources like water, dry season grazing areas and in general the spatial grazing range. As a result especially the increased contact with humans the animal numbers and the species diversity has reduced in the affected regions. In all the study sites wildlife is reported to decline.

We have observed remarkable decline in soil nutrients (also described as a decline in soil productivity in terms of crop yields) due to deterioration of chemical, physical and biological properties. The main reasons for the decline besides soil erosion are decline in organic matter (soil organic carbon), degradation of soil structure and reduction in availability of major nutrients (N, P, K) and micro elements and increase in toxicity due to acidification and salinisation especially in irrigated farming systems.

Impact of land use changes on sustainability of natural resources, biodiversity and land degradation

All across Sub Saharan Africa increasing population pressures have led to increases in cultivation and grazing intensity. This has led to massive deforestation and conversion of natural habitats to farmlands and settlements with implications on biodiversity and land degradation (Olson, Misana, Campbell, Mbonile, and Mugisha, 2004(a); Maitima, Reid, Gachimbi, Majule, Lyaruu, Pomeroy, Mugatha, Mathai and Mugisha, 2004). Deforestation is one of the most pressing environmental problems faced by almost all sub-Saharan African nations, with one of the primary causes of deforestation being wood utilization for fuel. Many sub-Saharan countries have had over three quarters of their forest cover depleted, and it is estimated that if current trends continue, many areas will experience a severe shortage of fuel wood by 2025. Deforestation also has negative implications for the local environment (increased erosion and loss of biodiversity). The highest rates of deforestation occur in areas with large growing populations such as the lake basin area and the surrounding highlands (Allen and Barnes 1985; FAO 2001; Tomberline, and Buongiorno, 2001; Achard, Eva, Stibig Hans-Jürgen, Mayaux, Gallego, Richards, and Malingreau Jean-Paul 2002; Geist and Lambin, 2002).

Productivity of farms has reduced in the intensively cultivated areas due to poor soils (Southgate 1990). In the areas where land is still available there are extensions of cultivations to replace the loss in production brought about by poor soils, but land subdivision is reducing available land slowly and the land use systems are becoming intensively managed.

Farming, grazing and settlements have expanded at the expense of native vegetation. As native vegetation is lost, indigenous plant and animal biodiversity and plant cover are lost. Sometimes, there are more species of birds, small mammals and plants in places where people used land in a moderate fashion. However, large mammals are universally lost as cultivation expands. As croplands expand, soil fertility and moisture drops and soils erode more easily. As plant biodiversity falls, soil erosion increases. Soils in dry lowlands are less fertile and contain less organic carbon than highlands soils. As farming and settlement expands, less water is available for people, and livestock. Irrigation for crops pollutes water sources. It has been established that in the Lake Victoria basin non point pollution caused by agricultural chemicals in the uplands is far more significant than even pollution from municipal wastes. Farmers who grow many crops conserve native plant species better than those who grow only one crop. Some farmers cope with land degradation by increasing crop diversity. Use of livestock manures and crop vegetative residues by

farmers maintains more fertile and more productive farms. An intensive study conducted by (ICRAF 2004) over several years has revealed a huge amount of loss of soil through erosion by water from the productive land into the lake. These massive soil translocations are facilitated by livestock grazing and movements. There is need for an urgent solution to reduce the rates of current soil erosion in the lake basin.

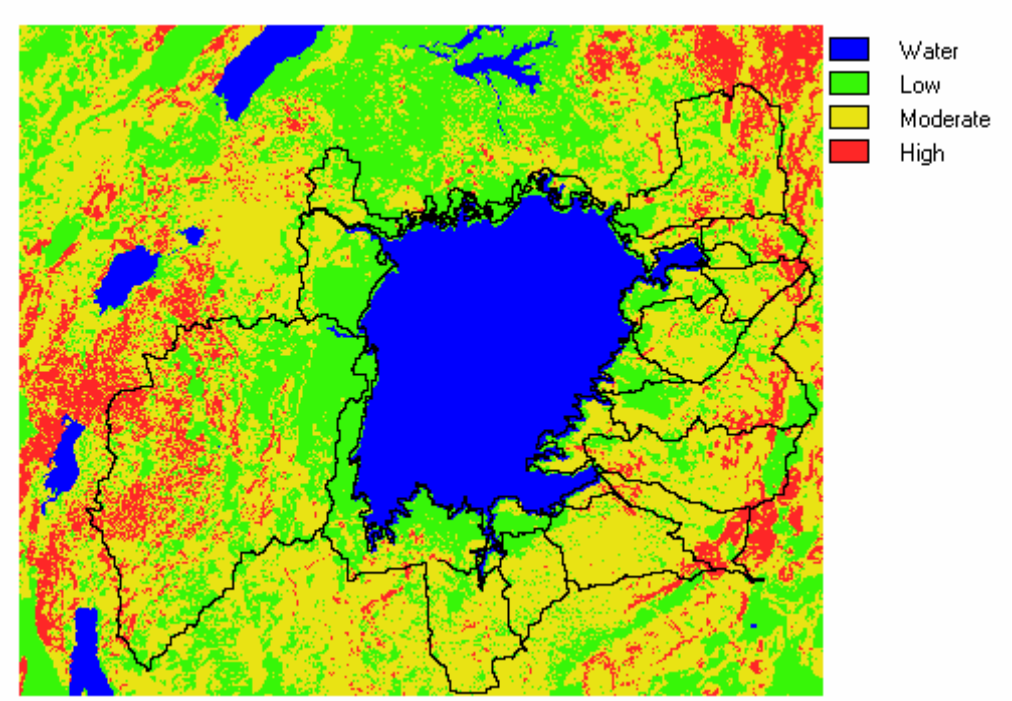
Impacts on agricultural production and livelihoods

Agricultural production has been practiced in the basin of Lake Victoria for many generations (Maitima and Gumbo, 2007). The most common mode of agricultural production is subsistence farming but due to several advances in strategic focus there is a potential for changes to commercial small and large scale farming like in many other parts of east Africa. However, availability of land is critical in this endeavor. Changes in land use have reduced the amount of land available for agriculture resulting in intensification of agriculture with implications for more farm inputs. This has confined grazing fields to smaller areas than before often leading into conflict between the cultivators and the herders. This has also led to heavier grazing pressures on land because livestock have to graze in an area for longer periods than before leading to more intensive grazing (UNEP, 2002).

Soil degradation and soil nutrient mining characterize many land-use types.

The most degraded parts of the landscape, both in terms of nutrient deficiencies and soil physical degradation, are areas currently used for open grazing and extraction of fuelwood. Areas currently used for subsistence agriculture are characterized by both types of degradation, but at lower prevalence rates than grazing areas. In part, the lower prevalence may be due to abandonment of severely degraded cropland. Proximal causes of degradation on croplands include low investments in physical or biological methods of soil conservation and low use of external sources of mineral fertilizers (ICRAF 2004). Figure 2 below shows the patterns of soil erosion in the lake basin. The highest erosion is on the escarpment slopes hill sides. Most parts of the basin experience high to moderate rates except in the flood plains and valley bottoms that experience low rates of erosions.

Fig 2. Model of erosion potential in the Lake Victoria Basin (ICRAF 2004)



Environmental problems in the Lake Victoria region

Lake Victoria is a vital natural resource. However, the usefulness of this resource has been severely strained by over-use and environmental degradation. Poverty is both cause and effect of the rapid and extensive deterioration of the region's environment. Soil erosion is a major problem as it not only removes fertile topsoil to the detriment of local agriculture but also contributes to eutrophication of the lake, which has become increasingly polluted due in part to the absence of viable sewage treatment facilities in the towns and lack of adequate sanitation in the rapidly growing townships in the countryside. Insufficiently treated or wholly untreated industrial waste adds to the burden of damaging nutrients in the lake and raises the level of heavy metals and toxins. Pollution by agricultural chemicals used in the intensifying and commercializing farming activities within the lake basin and beyond is a major cause for environmental problems of Lake Victoria.

Options for sustaining land productivity

Sustainable land management presents tools and approaches to develop and maintain equilibrium between production and the well being of natural systems in different landscapes, ecological conditions, political and socio-economic considerations. However, it may be necessary to make extra investments to identify and validate some of the tools to fit the circumstances prevailing in the lake basin. Specific areas of interest to the lake basin include: sustainable livestock production, sustainable forest management, soil management, and water management. Where such tools already exist in a sector based analysis efforts should be made in filing the gaps so that an integrated approach comprising of all natural systems, economic scenarios and social cultural situations, can be developed. If it doesn't already exists, there may be a need to develop a framework for sustainable land management in the lake basin taking

into account the different biophysical scenarios, socio-cultural settings, and political affiliations among the countries in the basin as well as those outside the basin .Soil erosion for example has been identified to be a major cause of land degradation and this is associated to livestock production. One big contribution Lake Victoria Resources management programme can do if resources are available is to work with partners like the International Livestock Research Institute (ILRI) and local organizations to develop and implement a framework and guidelines for sustainable livestock production in the lake basin. ILRI is working with Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) of the commission for African Union (AU) to identify and implement sustainable land use options in tsetse free areas of sub-Saharan Africa. A special focus on problems of livestock production in the lake basin would blend well with this continental initiative and would go along way into improving lands and livestock productivity for benefit of poor farmers.

To develop a balance between production systems, socio-economics and the underlying biophysical and chemical cycles the following approaches can be considered:

a) Application of ecosystems approaches in land management
b) Developing indicators to show changes in of environmental variables, productivity levels and human welfare status at different scales of the basin landscape.
c) Integrated assessments and monitoring of indicators in appropriate time scales.
d) Developing strong linkages between land users (e.g., communities), policy makers and other stakeholders like extension officers and technical experts working in the region
e) Regional harmonization of approaches among the member states and all the stake holders at decision making level and land management practices
f) Use of appropriate technologies in land management
g) Developing a system of responsibility and accountability among all keys players
h) Capacity building among land users on sustainable land management

To carry out the activities stated above effectively, there is need to combine efforts from all stakeholders with specific contributions in a synergetic manner where each one has a role to play. These stakeholders include but not limited to:

1) Regional Authorities and technical experts.
2) Investment partners and non-governmental organizations.
3) Relevant international and national research institutions.
4) Country lake basin authorities and other state agencies.
5) International, national and local private sector practitioners.
6) Government extension service providers.

7) Local communities and other land users.

Each of these stakeholders can play a role in fostering development in the lake region. For example identifying, evaluating and applying best land use options for Lake Victoria Basin, should start with synthesizing already existing information by relevant international and national research institutions; evaluating them with local communities, government agencies, development partners and applying them with all involved at various stages.

DISCUSSIONS AND CONCLUSIONS

In the basin of lake Victoria the abundant natural resources should provide a basis for pro-poor agricultural development if appropriate incentives are created by adjustments in national policies, reorientation of institutions and provision of public goods and services. The analysis of major farming systems in sub-Saharan Africa (Maitima and Gumbo 2007) indicates the relative importance of household strategies to escape poverty - in order of importance: diversification; intensification; increase in farm size; exit from agriculture; and, increase in off-farm income. In order to halve hunger and poverty by the year 2015, massive efforts are required to stimulate such growth, which ultimately depends on the initiative and efforts of many involved. Although it is impossible to prescribe specific national actions, the overall challenge of reducing hunger and poverty in the region demands four strategic inter-linked initiatives: sustainable resource management; improved access to resources; increased small farm competitiveness; and reduced household vulnerability.

Sustainable resource management: Sustainable resource management must address widespread land degradation, declining soil fertility and low crop yields resulting from inadequate rainfall; it should result in soil recapitalization and improved productivity. Components include farmer-centered agricultural knowledge and information systems to document and share successes; resource enhancements such as small-scale irrigation and water harvesting; participatory applied research focused on integrated technologies blending indigenous and scientists' knowledge, related to conservation agriculture, agro forestry, integrated pest management, crop-livestock integration; and strengthening resource user groups.

Improved resource access: Access to agricultural resources by poor farmers would create a viable resource base for small family farms. Components include: market-based land reform; adjustment of legislation; strengthened public land administration; and functional community land tenure.

Increased small farm competitiveness: Increasing competitiveness of small and poor farmers would build capacity to exploit market opportunities. Components include: improved production technology; diversification;

processing; upgrading product quality; linking production to niche markets; and strengthening support services, including market institutions based on public-private partnerships.

Reduced household vulnerability: Household risk management will reduce the vulnerability of farm households to natural and economic shocks, both of which are prevalent in African agriculture. Components include: drought-resistant and early maturing varieties and hardy breeds; improved production practices for moisture retention; insurance mechanisms; and strengthening traditional and other risk spreading mechanisms. Without these considerations the relationships between environment and poverty will remain that of a spiraling task and worsening conditions as endless efforts are made to eradicate poverty in the riparian region.

In conclusion: Land degradation is most rapid during the conversion of land use towards continuous cropping. The poverty/ land degradation relationship is real, reinforced by gender disparities.
The poverty/ land degradation spiral is not irreversible. As the agricultural sector becomes more profitable and other conditions more favourable, farmers invest in soil management.

Policies and programs may have a large impact during this transition period, when returns to investment in the soil may be met in the short to medium term. The situation is most critical in the marginal areas where vulnerability of the human and environmental systems overlap. This is where the mixed crop-livestock system is expanding, placing even more people at risk of productivity declines and highly variable rainfall.

As we seek solutions for these problems it is important to note a number of trends some of which are influenced by global changes. These include but not limited to:

- Land use change and intensification have allowed more people to live on the land, and the systems have shown flexibility in face of changing economic and political structures. Diversification, towards a mixture of crops and livestock, cash and food crops, and farm and non-farm income, will continue to be a critical means for households to reduce their risk in face of these changes.

- Economic analyses of returns to different land uses (livestock, crops) and land use modelling indicate that cropping will continue to expand particularly into semi-arid savannas, and irrigated cropping will expand. However, this needs to be done for the lake basin region so as to include the different land use options in the region.

- Expansion of cultivation does not necessarily lead to sustainable intensification and an increase in productivity. The situation is most critical in drier areas—where the vulnerability of the human and environmental systems overlaps and is in the processes of worsening.

- The future projects a drier and warmer environment around the basin of lake Victoria. This may have implications on crops productivity, human health, livestock disease, availability and quality of water and its resources.

- Urbanization is set to increase with projections of more than half of the population to be living in towns by 2020. While this may release pressure on land (lower population in the rural areas) the move to more commercial mono-crop type of farming will still pose a challenge on soil fertility, pollution due to chemical use and loss of biodiversity

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