A Review of the effects of population pressure on Watershed Management Practices in the Lake Victoria Basin

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ABSTRACT

Protecting the quality of soil and water while using these resources for the benefit of people is a major challenge in Uganda and indeed globally. Emphasis on agricultural sustainability arises out of increasing awareness about the finite nature of Uganda's arable land resources, the widespread problem of soil degradation, the rapidly deteriorating quality of the environment and the need to preserve soil and water resources for long-term use rather than for short term gain. The current population pressure on forests, swamps, rangelands and marginal agricultural lands leads to inappropriate farming practices, forest removal, and grazing intensities that, in extreme cases leave a barren environment that yields unwanted sediment and damaging stream flow to downstream communities. Watershed management is the process of guiding and organizing land and other resource use on a watershed to provide desired goods and services without affecting adversely the environment. The dilemma in watershed management in Uganda, and indeed globally, is that land use changes needed to promote the survival of society over long-term is at cross-purposes with what is essential to the survival of the population over a short-term. This paper reviews land management practices in the Lake Victoria basin and their impact on the environment. It addresses the current soil status; non-point pollution; timber harvesting/ deforestation; fire effects; grazing by livestock; and wetlands. Emphasis is laid on the effects of these practices on soil and water quality and the overall impact on the lake environment.

Key words: Water quality, farming systems, land degradation

INTRODUCTION

The current population pressures on forests, wetlands, rangelands and marginal agricultural lands leads to inappropriate cultivation practices, forest removal, and grazing intensities that, in extreme cases, leave barren environment that yields unwanted sediment and damaging stream flow to downstream communities (BOTORE, 1986). Compaction by livestock over the stream source areas increases the net output of water but reduces infiltration rate that aquifers are not recharged, spate flows are increased during the rains and stream flow fails in the dry season (HAMILTON and KING, 1983). Watershed degradation in many countries threatens the livelihood of millions of people and constrains the ability of countries to develop a healthy agricultural and natural resource base (FAO, 1986). HAMILTON and KING (1983) and PEREIRA (1986) concur that watershed management has a critical role in combating land degradation.

A watershed or catchment is a topographically delineated area that is drained by a stream system, i.e. the total land area above some point on the stream or river that drains past that point (*Gregersen et al.*, 1987). Watershed management is the process of guiding and organizing land and other resource use on a watershed to provide desired goods and services without affecting adversely soil and water resources (FAO, 1986). Watershed management practices are those changes in land-use, vegetation cover, and other nonstructural actions that are taken on a watershed to achieve watershed management objectives. The dilemma in watershed management in Uganda, and indeed globally, is that land use changes needed to promote the survival of society over long-term is at cross-purposes with what is essential to the survival of the population over a short term. Emphasis on agricultural sustainability arises out of increasing awareness about the finite nature of Uganda's arable land resources and the need to preserve natural resources for long-term use rather than short- term gain (MAGUNDA, 1993).

This paper reviews a number of watershed management practices in the Lake Victoria basin, in Uganda, and their impact on the environment. Special attention is given to the effect of management practices on water quality. This review addresses soils in the region, non-point pollution, wetlands, timber harvesting/ deforestation, fire effects, grazing by domestic livestock and future research in natural resources management. All these are evaluated from a soil and water management perspective.

A review

Soil and agro-climatic zones

Uganda has a wide range of soils, rainfall and altitudes, which give it considerable diversity and distinct agro-climatic zones. JAMESON and

MACCALLUM (1970) give an excellent account of the climate of Uganda. Uganda has equatorial and tropical savanna types of climate. Most of the country receives between 1015 mm and 1525 mm of rainfall per year. The Lake Victoria region and mountains of Bufumbira, Rwenzori, and Elgon receive higher amounts of over 2000 mm.

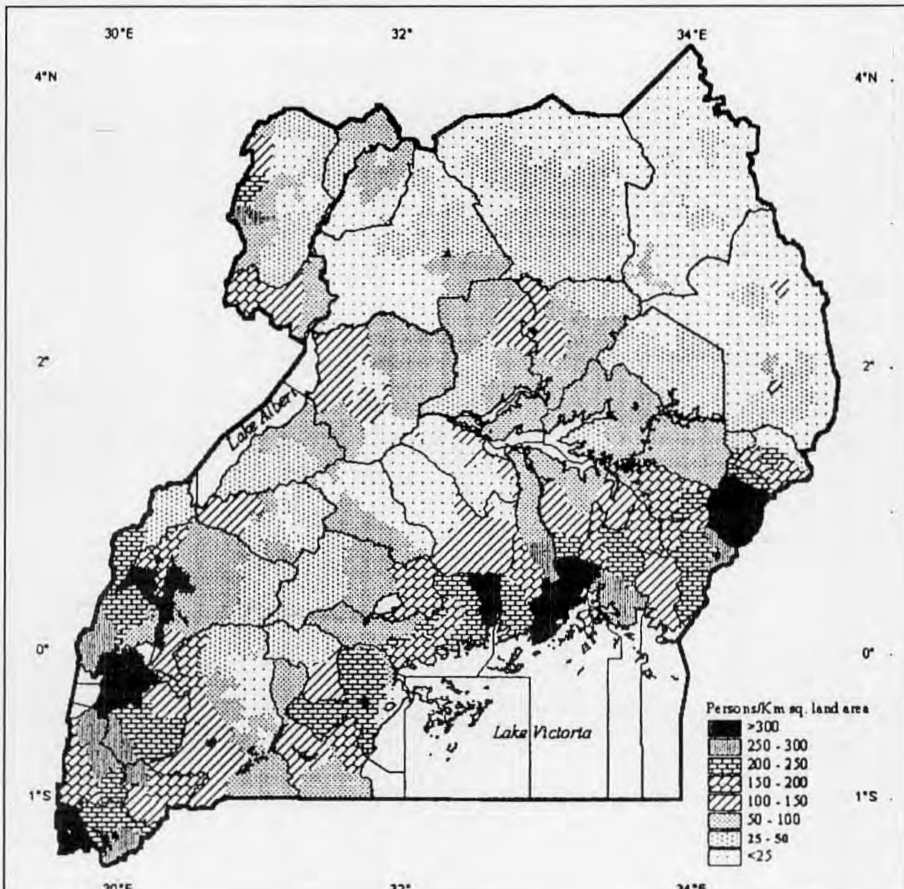

Figure 1. Population density of rural Uganda (Wortmann and Eledu, 1999)

While reviewing the previous 11 agro-climatic zones, Agricultural Research Group 4 (1987) noted that the section of the River Nile from Lake Victoria to Lake Kyoga divides the country into two generalised ecological zones. The north and north-east being characterized by light soils and natural vegetation dominated by short grasses which develop into open savanna forest and south west of the river generally have heavier soils and natural vegetation dominated by the tall elephant grass (*Pennisetum purpureum*), which with tropical forest

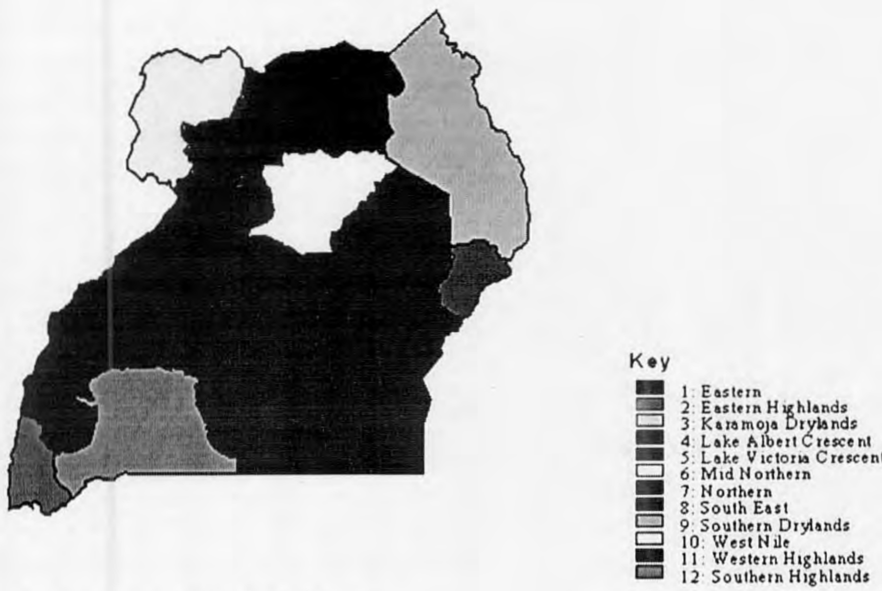

Figure 2. Uganda Agro-Ecological Zones (From NARO Strategy)

trees may develop into climax vegetation of closed tropical forests. These two areas are commonly referred to as the short grass and tall grass areas. By superimposing farming systems considerations and soil patterns on the two broad ecological zones, it was possible to review and rationalise the 11 agro-climatic zones originally defined by the Department of agriculture, into 4 broad agro-climatic zones, for the purpose of research services. Most recently NARO (2000) has further aggregated them and came up with 12 zones. Figure 2 shows the 12 major agro-climatic zones. The tall-grassland zone producing perennial crops in mixed farming systems basically dominates the Lake Victoria basin. The bare hills or pastoral areas in the "cattle corridor" area characterize the western segment of the cacthment.

The true Uganda soil resources are not fully known since only a reconnaissance survey was carried out during 1958-1960. The Lake Victoria basin is dominated by Udic and Aquic soil moisture regimes (SMR) and soil temperature regimes (STR) are isothermic and isohyperthermic. When the rainfall pattern is coupled with the SMR it becomes obvious that runoff / sediment yield from the basin should be high and most of these sediments should end up in the Lake Victoria eventually. Watershed management practices play a vital role in influencing quantities of sediment yield and how much eventually ends up in the lake.

Table 1 shows some typical soil data for different parts in the Lake Victoria basin. It is important to note that although the Lake Victoria basin is designated as 'fertile' the data presented reflects the contrary. A quick scan shows that the pH is generally low (critical level is 5.2 for Uganda soils) in several areas including Mabira forest. Other nutrients are also tending towards low levels. However, it is noted that organic matter is generally high (critical level for organic matter is 3% for Uganda soils) and this could readily find its way into rivers and lakes through soil erosion. The low nutrient status is generally attributed to continuous cultivation without application of fertilizers and inappropriate crop rotations / levy phases.

A quick scan of the data in Table 2 shows the high variability in textural composition. Textural composition helps in characterizing nutrient retention ability and water holding / retention characteristics. Sandy soils (> 45% sand) are generally more prone to the leaching of nutrients and have low water holding capacity. Such soils require very good management practices to be productive. There are extensive belts of sandy soils in the Lake Victoria basin. Those located in wetlands are generally poorly managed.

Impacts

1. Land degradation

The Lake Victoria basin is mainly (80%) an agricultural catchment (WORTMANN and ELEDU, 1999; MAJALIWA *et al.*, 2000). The human population within the catchment is increasing at a rate of about 3% annually. To feed this expanding population more food is required from the already cultivated lands. Unfortunately, however, farming is done at small scale (SFI, 1999), and on land of a quasi-marginal status (RUBAHAIYO, 1991; BEKUNDA and WOOMER, 1996) because of poor management practices (Zake *et al.,* 1992). Non-farming employment opportunities are limited; consequently restorative fallows are too short or inexistent. Forests, and bush are cleared; wetlands encroached to create space for human settlement, road construction, to respond to the new energy demand and, particularly farming activities. Similarly, pastoral areas subjected to a growing human and livestock number, degrade and face severe erosion (MAGUNDA *et al.,* 1999). As a result of soil erosion and nutrient depletion, a generalized state of soil and vegetation degradation and water bodies' pollution is set in the catchment.

Table 1: Soil data for selected parts in the Lake Victoria Basin

Location	pH (H_2O)	OM %	P mg/kg	K cmol/kg	Ca Cmol/kg	Mg cmol/kg	Source
Sango Bay	4.90*	8.06	10.00	0.10*	9.41	4.41	Agambe *et al.*, 1999
Jinja	5.00*	6.33	11.38	0.32*	1.88*	1.00*	Zake *et al.*, 1999
Luwero	6.60	5.22	1.75*	1.09	6.88	3.75	Zake *op.cit*
Entebbe	4.90*	2.00*	94.50	0.51	2.19*	1.20*	Zake *op.cit*
Buwaya	5.40	6.00	8.75	1.28	5.00	2.30	Zake *op.cit*
Mityana	6.20	5.37	29.50	0.13*	8.13	3.00	Zake *op.cit*
Mpoma	5.30*	2.70*	1.75*	0.77	4.38	2.00	Zake *op.cit*
Mabira	5.30*	6.00	-	0.30*	13.10	1.80	Yost and Eswaran (1991)
Rakai	4.5*	8.60	42.8	-	-	-	Majaliwa *et al.*, 2000
Kabanyolo	5.2*	4.31	1.66*	0.54	2.89*	1.67	Nkwiine *et al.*, 1999

Key: O.M: Organic matter, P: Phosphorous, K: Potassium, Mg: Magnesium, Ca: Calcium pH: Hydrogen potential

Table 2: Soil texture data for selected parts in the Lake Victoria basin

Location/ District	Clay	Silt	Sand	Source
Mabira forest	51.1	34.8	14.1	KARI
Buikwe	18.0	22.4	55.6	KARI
Mukono/ Ntawo	18.0	36.0	46.0	KARI
Mpigi / Nangabo	12.0	38.0	50.0	KARI
Kabanyolo	45.0	12.0	43.0	Zake *op cit.*
Mpigi / Mpigi	28.0	20.0	52.0	KARI
Mpigi / Maya (Swamp)	32.0	13.0	55.0	KARI
Mityana (swamp)	14.0	7.0	79.0	Zake *op cit.*
Mpigi / Migade	31.0	21.0	48.0	KARI
Kifamba/ Rakai	56.0	6.2	37.8	Majaliwa *et al.* ,2000

KARI: Kawanda Agricultural Research Institute

2. Point and non point sources of pollution

Point source pollution associated with industries or municipalities, whereby pollutants are discharged to natural water systems, is not discussed in this review paper. Watershed management is commonly associated with non-point pollution, which refers to pollution that occurs over a wide area and is usually associated with agricultural activities such as agricultural cultivation, grazing, forest management practices etc. It is important to note that urban runoff represents an important source of non-point pollution, but will not be discussed in this paper. Non-point pollution presents problems to resource managers, both from the standpoint of processes involved and procedures to eliminate, or minimize impacts. VIGNON (1985) points out that a major difficulty is understanding and analyzing the mode of conveyance. Other characteristics that challenge the analyst are the intermittent nature and the extent of non-point pollution. Identifying and quantifying the problem and finding solutions are difficult. As a result, best management practices (BMP), such as contour bunds, agroforestry etc., of watersheds have been identified as an approach to control non-point pollution. The BMP approach involves the identification and implementation of land-use practices in rural areas that prevent or reduce non-point pollution. Most of these practices are based on soil and water management attributes that promote water infiltration while reducing soil erosion.

Small-scale farmers, who do not, generally, use agricultural chemicals extensively, characterize farming systems in Uganda. Use of chemical fertilizers in Uganda has been declining (ZAKE, 1993). However in the Lake Victoria basin there are several large-scale farming operations that are a cause for concern for non-point pollution viz. Kakira sugar Estate, Lugazi Sugar Estate, various tea estates and the mushrooming number of horticultural farms. All these operations require high utilization of agricultural chemicals but no environmental impact assessment (EIA) has been made on any of these farming systems. The fast growing cut flower industry is located very close to the Lake Victoria fringes basically for two reasons: accessibility of water for irrigation and proximity to Entebbe airport for ease of export of flowers. These farms require constant monitoring of the tail waters that eventually end up in Lake Victoria.

3. Timber harvesting and deforestation

Land-use activities that alter the type or extent of vegetative cover on watersheds frequently will change water yield and, in some cases, maximum and minimum stream flow. When a forest is harvested, a number of important changes occur on a watershed that can change the concentration of dissolved chemical constituents in stream flow. Trees are no longer in place to take up nutrients from the soil and non-commercial parts of the trees left as logging residues increase the amount of decaying forest litter. In addition, the removal of forest canopies makes the site warmer while reducing evapotranspiration (ET). Less ET leads to an increase in soil water content, which, in turn, accelerates the activities of microorganisms, that breakdown organic material, including added slash. Water yield from a watershed usually increases when:

- Forests are clear cut or thinned,
- Vegetation on a watershed is converted from deep rooted species to shallow rooting species, and
- Vegetation cover is changed from plant species with high interception capacities to species with lower interception capacities.

The overall effect of deforestation / change of plant species because of population pressures is increased sediment loading to rivers and lakes in the basin. The sediment loads from such areas are normally high in nutrients and organic matter (FFOLLIOT and BROOKS, 1986). Unfortunately this area has not been investigated in Uganda and effects are only envisaged from the extensive deforestation that has taken place in the area and the concurrently reported increase in organic materials in Lake Victoria.

4. Fire and burning of slash

Most of the farming systems in the Lake Victoria basin are associated with slash and burn land management practices. Burning residues left in the forest timber harvesting produces an even greater increase in the release of ions from the forest litter and mineral soil than the harvesting operation itself. The increased release of ions is due, to a large extent, to the breakdown of organic materials into a soluble form, making them easily removable by leaching. However, in many instances, this increase is short lived (ZOLCINSKI, 1930).

5. Grazing by domestic livestock

Except where overgrazing has occurred in rangelands, grazing by domestic livestock generally does not have a significant impact on the dissolved chemical constituents in stream flow. However when animals become concentrated near water bodies, nutrient loading can be high. More often, the bacteriological quality of water can be affected by grazing of riparian communities.

Degraded rangelands are not extensive in the Lake Victoria basin. However, where they occur they are characterized by compacted soils with high sediment yield that leads to extensive siltation problems (MAGUNDA *et al.*, 1999; MAJALIWA *et al.*, 2000). The barehills in the districts of Rakai, Sembabule, Mbarara and Ntungamo are typical degraded rangelands that require urgent attention/ rehabilitation. Some of these areas are communally grazed and hence there are several socio-economic constraints that need addressing.

6. Wetlands degradation

Wetlands, also known as swamps, are one of the most fragile resources of Uganda and the largest extent is in the central part of the country, around Lake

Kyoga and the banks of Lake Victoria. The hydrologic characteristics of wetlands are:

- Shallow water tables and flat topography,
- The depth of water table governs ET and stream flow discharge from wetlands. The deeper the water table the lower the ET and discharge,
- Annual ET far exceeds annual discharge for most wetlands,
- Wetlands tend to be ground water discharge areas and not recharge areas,
- Because of the flat topography wetlands function as simple reservoirs; they attenuate floods peaks by temporarily storing or detaining water.

Riparian communities are associated with wetlands i.e. plants that grow adjacent to streams or lakes and often have root systems in close proximity to the water. Although riparian vegetation consumes large amounts of water, including ground water, such communities often are valuable for stream bank protection, wildlife habitat and protect adjacent aquatic ecosystems. Under most conditions, the riparian communities along streams and lakes are best left alone or even protected from logging, grazing and other types of exploitation.

Wetlands in Uganda are dominated by histosols, fluvisols and gleysols. Although these soils may be relatively fertile they require special management skills because of the ability, of some of them, to become acidic on drainage (Acid Sulphate soils or Sulfaquents). Lack of research / advisory services, in this area, had led to extensive drainage of swamps that should otherwise not have been drained. There is an urgent need to monitor and evaluate soil properties, soil productivity, hydrologic processes and health impacts of wetlands utilization. Fortunately the need for baseline survey, to determine areal extent and potential of utilization of wetlands, is now well recognized in Uganda.

Table 3 shows analytical data of reclaimed swamps in Uganda. The pH of 2.3 for soils from Kabale (Mr Batuma's farm) is typical of Sulaquents i.e. swampland that should not be drained at all). Several nutrients are also below the critical levels.

Land use and water quality monitoring

There is very little work done, in Uganda, in the area of soil and water quality monitoring in relation to watershed management. The land use management research under Lake Victoria Environmental Management Project is a start in

Table 3. Soil data for selected swamps in Uganda

Location	pH (H_2O)	OM %	P mg/kg	K cmol/kg	Ca cmol/kg	Mg Cmol/kg	Source
Kabale	2.3	42.0	2.63	0.19	0.65	0.10	Zake 1993
Kibimba	5.8	3.70	10.30	1.02	8.75	4.20	Zake 1993
Maya	4.5	1.90	3.00	10.00	33.00	-	KARI
Mityana	3.6	1.10	-	2.00	5.00	-	KARI
Migade	4.2	11.1	4.00	10.00	33.00	-	KARI

Key : KARI (Kawanda Agricultural Research Institute – Kampala/ Uganda)

the right direction to establish relationships between land use and water quality. A good monitoring program should define the problem explicitly (characteristic to measure) and define goals and objectives. Monitoring programs may be aimed at:

- Cause and effect monitoring to determine effects of specific actions on water or soil quality e.g. effect of deforestation on water quality,
- Baseline monitoring to determine trends overtime,
- Compliance monitoring to determine if water quality standards are being met, and
- Monitoring inventory to establish existing water or soil quality conditions and other statistical considerations.

CONCLUSION AND RECOMMENDATIONS

Research in watershed management, and indeed most natural resources, is very limited in Uganda. The majority of sectors in natural resources management research are poorly manned. Natural resources management research benefits are usually long term and consequently did not in the past attract attention of development partners who preferred 'immediate impact programs'. It is however gratifying to note that trends have changed for the better.

Although Uganda has a wide range of soils, rainfall and altitudes, which give it considerable diversity, management of these resources is still poor. The multiple use concept represents a practical means of achieving watershed management benefits while diversifying and increasing the level of income. The scientific community must develop technologies to (a) reduce input while maximizing economic returns, (b) decrease soil degradation, (c) minimize risks of pollution of natural waters and environment, (d) restore productivity of degraded land and (e) maintain productive capacity of existing land by preserving soil's life support processes. The BMP is an approach that has much to offer to make the systems sustainable.

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