Lake Victoria Environmental Management Project (LVEMP)

Survey and Mapping of Land Use/Cover and Erosion Hazard in Lake Victoria Basin

Final Report
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Regional/National Secretariat
P.O. Box 78089
Dar es Salaam

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ACRONYMS

LVEMP	Lake Victoria Environmental Management Project
IRA	Institute of Resource Assessment
MoAFS	Ministry of Agriculture and Food Security
UNHCR	United Nations High Commision for Refugees
DTM	Digital Terrain Model
GPS	Global Positioning System
FAO	Food and Agriculture Organisation
UTM	Universal Transverse Mercator
USLE	Universal Soil Loss Equation
NGO	Non-Government Organisation
CBOs	Community Based Organisations
MCH	Mother Child Health
ECF	East Coast Fever
HIV/AIDS	Human Imuno-deficiency Viruse/Aquired Immuno-defficiency Syndrom
URT	United Republic of Tanzania
NARCO	National Ranching Company
STAMICO	State Mining Corporation
KAEMP	Kagera Environmental Management Project

SDC	Serengeti District Council
FMD	Food and Mouth Diseases
BQ	Black quarter
DNRO	District Natural Resources Officer
TANICA	Tanganyika Instant Coffee Company
STDs	Sexually Transmitted Diseases
STIs	Sexually Transmitted Infections
KAEP	Kagera Environmental Project

EXECUTIVE SUMMARY

This study has provided the spatial extent and magnitude of the soil erosion in the basin and identifies priority areas for immediate interventions. Such areas are referred in this report as *hot-spot* areas. It has also examined the main factors that have contributed to the present land use practices, and the associating environmental degradation processes, and mapped erosion hazard in the basin. It has been realized that soil erosion is one of the main processes of land degradation which lead to depletion of soil nutrients in agricultural land, and degradation of wetlands through siltation and sediment deposition. The report suggests various mitigation measures that can be implemented to minimize the risks of soil erosion in the basin.

The study has confirmed that agriculture is still the backbone of the economy for the majority of the population in the basin. Despite the importance of agriculture, there has not been much technological advancement in the sector. Poor agronomic practices including extensive and shifting farming still persist and influence soil erosion processes as a result.

Among the various human activities that are practiced in the basin, extensive cultivation, mining, lumbering, charcoal making, and livestock keeping have destructive effects to land cover because of the ever increasing demand to meet the rapidly growing human population. Increased population density is often associated with expanded human activities and expanded deforestation processes. The use of traditional farming systems, for example, facilitates environmental degradation and soil erosion in particular. Similarly, the environmental implications of mining activities include large-scale deforestation and destruction of the land through digging. Further, large herds of cattle lead to overgrazing and serious land use conflicts. The expansion of agriculture in areas that were traditionally used for grazing purposes has enhanced serious land use conflicts especially between agriculturalists and livestock keepers. The consequence of such conflicts is overgrazing leading to sheet and gully erosion. These observations leads us to a conclusion that soil erosion is to a great extent a function of human activities in pursuit of their livelihood.

Findings from this study indicate that the influence of soil degradation factors to the actual or potential degradation varies from place to place. Thus, there are areas where degree of slope is the major factor while in other areas soil physical characteristics was seen to be the major factor. Such variations necessitate varying amelioration strategies and approaches in studying or accessing soil erosion hazards.

Human-induced vegetation cover is one of the remarkable features observed in the basin. Deforestation processes have been reported since early 1860s, through expansion of the agro-pastoralism farming system, especially in Sukumaland. Such practiced were fuelled by the colonial administration through tsetse large-scale tree felling exercises. The other factor contributing to the alteration of the natural vegetation cover of the basin is uncontrolled harvesting of forest products through charcoal making, timber and large-scale fuel wood gathering for sale. The destructive nature of these activities is witnessed along the Kahama-Ngara highway. Fishing is another important economic activity that

facilitates deforestation, hence, increasing the soil erosion potentials. The use of traditional fishing gears and fish processing techniques necessitate availability of huge amount of wood, often from the natural vegetation in the basin.

Dense settlements are largely found on good agricultural land. This feature is demonstrated in Muleba, Bukoba, Biharamulo, Geita, Tarime, and Sengerema Districts where the highlands and the lakeshore are densely populated. Evidence also shows a tendency of people migrating from the eastern part of the basin towards the western part where large forest reserves and mining activities prevail. Evidence from Biharamulo District show an influx of migrants from various parts of the country and neighbouring countries searching for arable land, pasture, and other income generating opportunities like lumbering, charcoal making, hunting, and beekeeping.

Similarly, areas with mining activities also experience high population pressure. This is demonstrated by the observed rapid growth of Geita town especially after the reestablishment of gold mining activities leading to increased burden over social services and high demand for products from natural resources. Serious deforestation and land degradation were observed around mining sites. Rapid urbanisation and unplanned settlement patterns especially in regional headquarters is a big environmental hazard as it contribute to clearance of vegetation cover and accelerate environmental degradation processes.

Karagwe and Ngara District experienced an influx of huge refugee populations in the 1990s. The negative impacts of the refugees include massive deforestation in areas surrounding the camps, vandalism of social service facilities, increased food insecurity, high commodity prices, social insecurity, and high risks of HIV/AIDS infections. Apart from refugees from Rwanda and Burundi, migrants from Uganda also enter the basin mostly in search of pasture. These are causing land pressure or land shortage in the basin.

Most parts of Kagera Region practice land management systems that are sustainable. The Kibanja system, for example, comprises of a mixture of banana, coffee, beans, maize and many other annual and tree crops. Fallowing is often practiced in the Kikamba system where land is sometimes left fallow and used for annual crops.

There is also evidence of declining crop production in many parts of the basin. The decline in production is largely caused by the declining use of agricultural inputs due to non-availability and/or high prices. The decline in use of inputs is mainly attributed to the removal of subsidies on agricultural inputs and poor performance of cooperatives in relation to marketing and supply of agricultural inputs. Farmyard manure and mulching practiced are used in areas like Bukoba, Ngara and Karagwe to replenish the soil fertility in farms.

Passive soil erosion factors constitute inherent features of the natural environment, which if disturbed give rise to accelerated soil erosion. There is evidence of erosion even on the gently sloping areas and those with minimum human interference. Some soils are severely eroded through rill and gully erosion and that highly eroded catchments contribute more sediment into the lake.

Almost every household in the basin is dependent on fuel wood as a source of energy for domestic purposes; as a result the impact of energy demand on forest resources is

immense. This situation is aggravated by rapidly increasing population due to natural population growth and the influx of refugees.

Differences in farming systems seem to be a function of variations in climate (rainfall, temperature, etc.), altitude, demographic factors, geology and landscape (terrain). In Kagera Region, for example, the widely used practice of heavy mulching on the cultivated slopes is very effective in controlling soil erosion caused by rain-drop impact and surface wash. Mulching in banana and coffee fields is applied to reduce evapo-transpiration and increase soil nutrients. The farming systems in Biharamulo District are based on cotton, cassava, sweet potatoes, maize and bulrush millet. In Ngara District the farming systems based on banana, maize, beans and other legumes and some farmers practice shifting cultivation which leads to clearing of vegetation. Farming systems in Mara, Mwanza and Shinyanga Regions are based on cotton, maize, rice, sorghum and cassava, with livestock playing and important role especially for draught power. In these regions, demographic pressures have played a role in influencing changes in the farming systems. Traditional farming systems involving unsustainable agricultural practices e.g. shifting cultivation and cultivation along the slope are among the major causes of land degradation in general and soil erosion in particular.

1.0 Introduction

In Tanzania, like many other developing countries in Africa, agriculture is the backbone of the national economy as it contributes more than 90 percent to the GNP. Furthermore, the majority of Tanzanians live in rural areas depending on agriculture and livestock keeping as their major occupations. Despite such importance of agriculture to the national economy, there has not been much technological advancement in agricultural sector. For example, extensive farming system has continued to be the common practice, particularly in areas with abundant land (low land pressure). Such practices have consequently led to the continuous clearing of natural vegetation leading to land degradation.

During the inception of the Lake Victoria Environmental Management Project (LVEMP), soil erosion was recognised to be among the most serious environmental problems in the basin. It was on this basis that a Soil and Water Conservation Sub-Component of the LVEMP was established. The sub-component is being implemented by the Soil Conservation and Land Use Planning Unit of the Ministry of Agriculture and Food Security. Among the activities to be implemented are surveying and mapping land use/cover, and soil erosion hazard in the Lake Victoria basin part of Tanzania. The Institute of Resource Assessment (IRA) was commissioned to collaborate with the Ministry of Agriculture and Food Security (MoAFS) to undertake this activity.

Although soil erosion was known to be a serious problem in the basin, spatial extent and magnitude of the problem was not known. This made it difficult for LVEMP to identify priority areas for immediate intervention and design appropriate conservation packages. Results from this study would provide the basis for designing appropriate conservation packages.

The main objective of this study was, therefore, to identify present degraded areas which are potentially vulnerable to soil erosion for immediate intervention. The specific objectives of the study were:

- To map the current status of different land use/cover types,
- To examine factors contributed to the present land use types and the associating environmental degradation processes, and
- To map erosion hazard in the basin.

This report is in six parts. Part one consists of an introduction which provides background to the study. Part two elaborates on matters of methods adopted during fieldwork and data analysis phases. Part three presents the profile of the Lake Victoria Basin part of Tanzania and focusing on biophysical and socio-economic factors and indicators of soil erosion. Part four describes the soil erosion hazard in the Lake Victoria Basin part of Tanzania. Part five discussed the management practices in different farming systems. Part six outlines the conclusions and recommendations.

This study was based on realisation that soil erosion is one of the main processes of land degradation in the Lake Victoria Basin. The process leads to depletion of soil nutrients in agricultural land, degradation of wetlands through siltation and sediment deposition into the lake affecting fish habitat. Through this study, the most affected areas (hot spots) have been identified and the possible mitigation measures have been proposed. Land use/cover

maps together with other information like terrain, socio-economic variables formed a basis for developing erosion hazard maps based on the established methodologies in the literature.

Within the study area there are a number of human activities that are likely to influence changes in land use/cover. These activities include the cultivation of crops like cotton maize and coffee, mining, lumbering, charcoal making, livestock keeping, brewing. These activities have had notable impacts on land use/cover. This is particularly so because of the increasing demand for food to meet the rapidly growing human population. In addition, the demand for forest products has been increasing especially in urban areas.

Similarly, mining activities have increase, especially in Geita, Kahama, Kwimba, Tarime and Biharamulo Districts. The environmental implications of mining activities in the basin are enormous. This study has identified the extent to which mining activities have affected the environment leading to serious erosion processes. It has been observed that there are many areas that were covered with woody vegetation in the past but have been converted into farmland, grassland or even bad or marginal lands due to poor mining techniques**.**

Livestock keeping is also a major socio-economic activity in the study area. Large herds of cattle are kept, especially in Kwimba, Magu, Tarime, Ngara, Karagwe and Geita Districts. In most of these areas pastures have become scarce due to rapid increase in livestock population and expansion of agricultural activities, leading to overgrazing and serious land use conflicts.

2.0 Materials and Methods

The sampling criteria of study units was based on different resource endowment and use patterns in the basin, which led to the selection of the hotspot areas in the respective districts. These units were established through a combination of the following bio-physical and socio-economic factors/parameters:

- Slope characteristics
- Rainfall erosivity
- Soil erodibility
- Land use/cover types
- Catchment areas of different river systems draining into the basin
- Farming systems in the basin
  - Agriculture (coffee, banana, cotton, maize, etc)
  - Livestock keeping
- Agro-ecological zones
- Fishing
- Mining
- Demographic parameters (migration, population growth, refugee influx)
- Urbanisation
- Wetlands

Reconnaissance fieldwork was undertaken in the basin in order to get the general impression of the basin and identify specific or hotspot areas for detailed investigation. Preliminary data and information was collected from all relevant offices at regional and district levels which include government and parastatal organization/institution offices as well as offices of the private sector, CBOs, NGOs, Village Government leaders, and staff from research centers. It was on the basis of this reconnaissance fieldwork the administrative units (divisions/wards) in the districts of the four regions, namely Kagera, Mwanza, Mara and Shinyanga were selected for in-depth investigation. These areas are already experiencing varying degrees of soil erosion or have the potential soil erosion hazards.

Subsequently, the second field work was undertaken during which in-depth investigation study in specific or hot-spot areas was made on relevant socio-economic factors that influence soil and water conservation as well as land/soil degradation with respect to soil nutrient depletion and soil physical characteristics destruction. The fieldwork involved detailed bio-physical as well as socio-economic data collection. These factors include human and livestock population pressure and dynamics; farming systems; agricultural practices; non-agricultural economic activities (which include fishing, mining and petty trade/business); and natural resource utilization which covers forests, land and water. An in-depth investigation was also made on pertinent socio-economic services/infrastructures such as extension services (agriculture, forestry, fisheries etc.). Impacts of refugees on the environment in and around refugee camps were also investigated. The methodological approaches are described in Sections 2.1 and 2.2.

2.1 Bio-physical aspects

2.1.1 Sources of Data

Primary data include those which were extracted from interpretation of satellite imagery and aerial photographs, and field observations as were made during ground truthing. The project acquired Landsat 7 data (1999) from EROS Centre in the United States. The images are Satellite Images Maps in that they are already geo-referenced to corresponding base topographical maps of 1:250,000. Bands 3, 4 and 5 were combined to produce false colour composite. This combination has previously proved to be useful in other similar studies.

Secondary sources of data include various reports collected from the districts and institutions involved in environmental related activities in the basin. Contour maps at 1:250,000 and 1:50,000 scale were digitised and these formed a basis for generating Digital Terrain Models (DTM) which was used in generating slope classes.

2.1.2 Interpretation of Satellite Image Maps

Though computerized classification of satellite data is time saving, it is not reliable in areas with heterogeneous terrain and land uses (Shishira et al, 1997). Therefore, manual (Visual) interpretation was used. The interpretation was divided into two stages. The first stage was preliminary interpretation where major topographic features and the general land cover/use types were identified. The second stage involved final interpretation after field verification. Interpretations were made on transparent films for each layer or coverage. In order to maintain consistence in the classification of land use/cover types, the interpreters first interpreted one or two satellite image collectively so as to ensure consistency in the identification of features and their coding.

2.1.3 Field Verification

Reconnaissance field verification/observation was carried out through traversing along the existing road network. Tonal signatures on the 1999 satellite images formed a basis for identifying areas for field annotations. The field traverses were conducted from a known point. Entry and exit from land cover units was recorded against vehicle speedometer readings. The geo-reference of each starting point, way-point and end-point of each traverse was recorded using a GPS. All traverse information such as land cover and land use, slope characteristics, geology and soils, were noted on the pre-prepared form to aid final interpretation.

Detailed fieldwork involved in-depth data collection of various types of environmental information for specific areas. Such areas were identified after the compilation of data collected during the reconnaissance field survey and final satellite image interpretation. A number of map units were identified for in-depth investigations. Aspects covered were; land cover, land use, soil type, slope characteristics, farming systems and land management practices. Particular attention was paid to areas mapped as having high soil erosion hazard so as to ascertain the extent and magnitude of soil erosion. Datasets generated for these different soil erosion factors were coded to reflect levels to which they were considered to influence soil erosion.

2.1.4 Digitization

The transparent films obtained from thematic interpretation of different layers were digitized using ArcInfo software. Further manipulation of digitally captured datasets e.g. area statement computation was done using ArcInfo, ArcView, CorelDraw, and Microsoft Excel.

All digitized data sets underwent the following processes:

- Creation of raw digitized coverage
- Cleaning of the coverage (identifying errors)
- Editing of the coverage (correcting errors)
- Transformation of the coverage to UTM projection
- Checking for sliver polygons and editing-out
- Coding of polygons
- Clipping of the coverage (to allow-edge-matching to adjacent sheets)
- Edge match editing
- Production of color plot and checking
- Generation of the final coverage and copying

The end products are maps, tables, histograms etc. Scales of the maps produced conform to the requirements stipulated in the Terms of Reference.

2.1.5 Assessment of Erosion Hazard by Overlay Method

This method was used to assess the distribution and severity of soil erosion and involved overlaying layers of information representing variables influencing soil erosion. These variables are; slope characteristics, rainfall erosivity, soil erodibility, and land use/cover types. Each factor was re-classified on the basis of significance of influence to soil erosion and ranked as 1-insignificant, 2-significant, and 3-very significant. A matrix of these values for each of the factors was generated and the mean of these values in a given geographical location was used to indicate severity of erosion. Again, 0-1 was ranked to be insignificant, 1-2 was ranked to be significant and 2-3 was ranked to be very significant.

2.1.5.1 Slope Characteristics

Contours on the topographic maps were digitized and transformed into digital terrain model (DTM). It is from the digital terrain model that slope classes were developed based on FAO Classification System. Slope is among the factors contributing to land vulnerability to soil erosion. In this regard, steep areas are potentially more vulnerable to erosion than flat areas. Slope classes developed for this study are shown in Table 1 below**.**

Table 1: Slope Classes

Rating Unit	Slope Class	Percentage	Degrees
1	Flat to gently sloping	0-6	0-3
2	Sloping to moderately steep	6-25	3-14
3	Steep to very steep	More than 25	More that 14

Source: Extracted from FAO (1977)

2.1.5.2 Rainfall Erosivity

As noted above, rainfall is another set of information to be integrated in the identification of erosion hazard areas. Rainfall intensity has a direct link with the extent to which it can enhance soil erosion in a given area. A coverage on rainfall distribution pattern in the catchment has been captured by digitising the existing rainfall distribution pattern in Tanzania (Moore, 1979).

According to the rainfall erosivity map developed by Moore (1979: 154), areas around the western and southern shore of Lake Victoria fall within the highest erosivity hazard zone (10,000 – 18,000 J/m^2.yr). The rest of the basin falls within the lowest erosivity hazard zone (6,000 – 10,000 J/m^2.yr).

2.1.5.3 Soil Erodibility

Similarly, different soils have different vulnerability to erosion. Knowledge of soil properties is therefore important as a key for understanding soil erodibility. Information on soils has been extracted from the soil database for Tanzania developed by De Pauw (1984). It was from this data set that soil units were coded as indices for erodibility. Coding ranging from 1 to 3 value represent magnitude of erodibility for different soil types.

2.1.5.4 Land cover/use types

Land use/cover types are among the factors normally considered in assessing potential soil erosion hazard. Different use/cover types have different effect in protecting soil from water erosion. Land cover/use types generated were therefore coded basing on the levels to which different types can enhance soil erosion. Coding range between 0 and 3 values. 0 value represent cover types that are not applicable, such as water bodies, swamps, etc.; 1 represents cover types that have high conservation values like all protected areas, dense vegetation cover; and 3 represents land cover/use types that have minimal conservation value such as cultivated areas. Table 2 summarizes these values with their corresponding conservation values.

Table 2: Land cover/use types with corresponding conservation values

Rating Unit	Cover Type	Soil Conservation Value
1	Areas with vegetation/tree crop cover greater than 60 percent	High
2	Areas with vegetation/tree crop cover between 20 percent and 60 percent	Moderate
3	Areas with vegetation cover between 20 percent or with herbaceous crops	Low

2.1.6 Assessment of Soil Erosion by Universal Soil Loss Equation (USLE)

The USLE erosion model was used in this study to estimate magnitudes of soil erosion in the basin. The model is based on the contributions of rainfall, soil erodibility, length of

slope, degree of slope, management, soil conservation practice in total soil loss due to erosion. According to this model, total soil loss by erosion is a function of the above factors expressed by A = C.K.LS.R.P, where A is soil loss, C is vegetation factor, K is soil erodibility, LS is slope, R is rainfall erosivity, and P is management practices. Results from this model are presented in Section Four of this report.

2.2 Socio-Economic Aspects

Soil erosion as one of the manifestations of land or environmental degradation is to a great extent a result of human activities in pursuit of their livelihood. Therefore, in order to understand fully the prevailing human activities taking place in Lake Victoria Basin, which are root causes of land/environmental degradation, socio-economic survey was undertaken in communities residing in the basin. This exercise was necessary in order to determine the socio-economic changes that had taken place or are taking place now and their indicators and also those changes that are likely to take place in future.

Socio-economic surveys were conducted to establish the drivers of changes in land cover and hence, triggering of erosion processes. Socio-economic information were essential for explaining the various behavioral aspects of the local communities and the erosion hazards in the study area for effective and efficient environmental protection. In order to capture the socio-economic information, various approaches were used. These include in-depth investigations, review of existing literature, and discussions with various stakeholders. In-depth investigations on the performance of the relevant government ministries, parastatal organizations, NGOs, CBOs, and religious institutions involved in the provision of the socio-economic infrastructures/services to the communities were made. These activities were accomplished by visiting these offices and making discussions with the officials concerned.

Given the fact that agriculture is the major economic undertaking of the population in the Lake Victoria Basin, there was need to conduct in-depth studies on various aspects related to agriculture and agricultural practices. It has been identified that the use of traditional farming systems is one of the major causes of environmental degradation in most communities in the basin. Farming systems that comprise of a range of farming practices as well as technologies were investigated in order to determine their impacts on the environment in general and soil erosion hazards in particular. Moreover, the investigation of the agricultural practices and changes and livelihood patterns in different parts of basin was made. This included assessment of the cropping patterns, agricultural inputs, and implements used. Such observations were made to ascertain whether or not farmers practice mixed/mono-cropping, permanent/shifting cultivation, inter-cropping, and intensive/extensive cultivation.

Irrigation farming, wetland utilization for agricultural purposes, as well as soil and water conservation measures used by farmers were also investigated. Observations were also made on the types of crops grown, agricultural inputs used (organic/inorganic fertilizers, pesticides, insecticides, herbicides, improved seeds, etc.), implements used (hand hoe, ox-ploughs, tractors, etc.). Soil and water conservation measures practiced by farmers were also studied.

Most if not all, environmental changes that are currently observed in the basin are induced by human activities. These activities include the provision of essential needs for

his livelihood such as food, shelter, clothing, etc. Since the influence of demographic factors to the erosion hazards and potentials was noticed to be important, it was necessary to investigate issues such as population size and its characteristics, the migration patterns, population density, growth rates, and spatial distribution and trends.

3.0 District Profiles

A remarkable feature of the environment of the Lake Victoria Basin in Tanzania is the dominance of human-induced vegetation cover types. Reports by travellers through the area indicate that as early as the 1860s, a vast area in the heartland of Sukumaland had already been cleared of its original vegetation through expansion of the agro-pastoralism farming system practised by the Sukuma people (Merteens et.al., 1995).

During the British colonial administration this cleared up area came to be referred to as the "Cultivation Steppe", on account of its striking lack of trees (Malcom, 1953). The cultivation steppe has, and is increasingly expanding westwards at the expense of miombo woodlands; and eastwards at the expense of thorn bush/woodland. Expansion of the cultivation steppe is a consequence of increasing human and livestock populations, and bush clearing as a tsetsefly eradication measure.

Where the normally flat or undulating landscape which characterise large areas of the Lake Victoria Basin is interrupted by hills and ridges, the upper slopes of such hills and ridges are commonly associated with extensive coverage of rock outcrops hindering any form of cultivation practice. Hill and ridge crests are therefore largely bare where rock outcrops dominate. Where the individual rock outcrops are interspaced with patches of relict soil, the later may normally support grass, or bush, or even scattered trees. Where the hill/ridge slopes have been steeply dissected as in western Biharamulo and Ngara Districts, rock outcrops and their associated "patchy" vegetation cover extend all the way down to the footslopes. Under this situation, cultivation is only practised on the narrow valley floors. Elsewhere in the basin, drainage depressions are normally very wide and flat. Where these wide depressions only seasonally flooded, grassland or bushland with scattered cultivation dominate. The permanently flooded depressions constitute bogs or swamps, which are often covered by papyrus and reeds.

The other factor contributing to the alteration of the natural vegetation cover of the basin area is uncontrolled harvesting of forest products. Charcoal making is particularly destructive as witnessed along the Kahama-Ngara highway. Here, large areas previously covered with closed Miombo woodland is actively being turned into shrubland through charcoal making and harvesting of fuelwood.

The area covered by the Terms of Reference, namely the Lake Victoria Basin in Tanzania is shown in Figure 1. The elevation and relief vary considerably, from the hilly regions in the west and east to the plains of Sukumaland in the south and the Serengeti plains in the east, which lie only a few tens of metres above Lake Victoria.

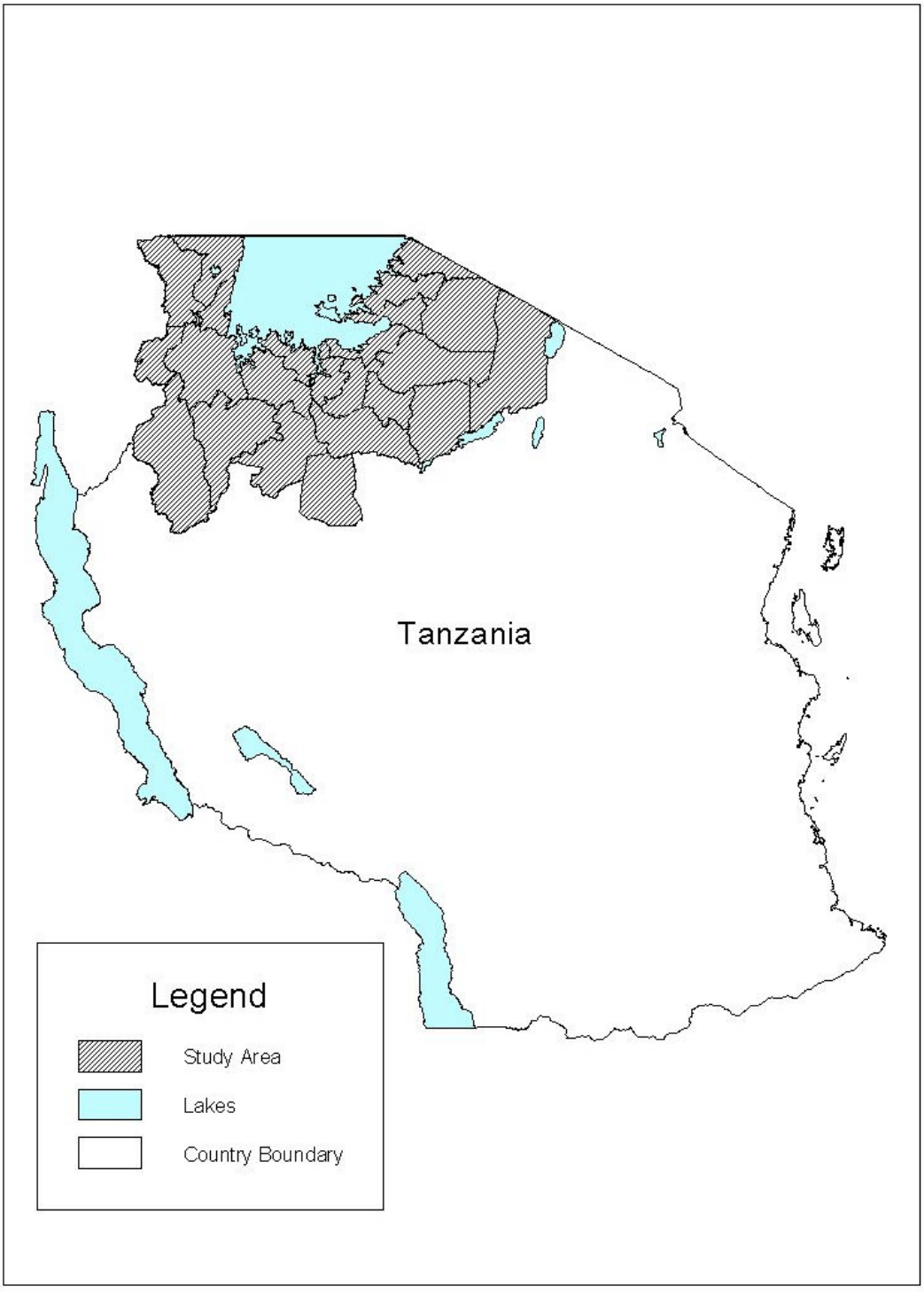

Figure 1: Study Area – Lake Victoria Basin

Most of the Lake Victoria Basin receives rainfall between 600 and 1000mm per year. The exception is the area around Bukoba town which receives up to 2000mm per year and part of Tarime district which receive up to 1200mm per year (Moore, 1979). Except for the Kagera and Mara rivers, and in most years, the rivers are seasonal and there is no flow in the dry season. Discharges are generally variable and floods are a frequent occurrence during the rains.

The area comprises of six administrative regions, namely Kagera, Mwanza, Shinyanga, Mara, and part of Arusha (western part of Ngorongoro). The regions are in turn sub-divided into districts.as follows;

3.1 Kagera Region

Kagera Region is located on the North-Western corner of Tanzania. The region has 7 Districts with an estimated population of about 1,849,965 in 2000 (URT, 1998). Figure 2 shows the trends in population increase in Kagera Region between 1967 and 2000 by districts.

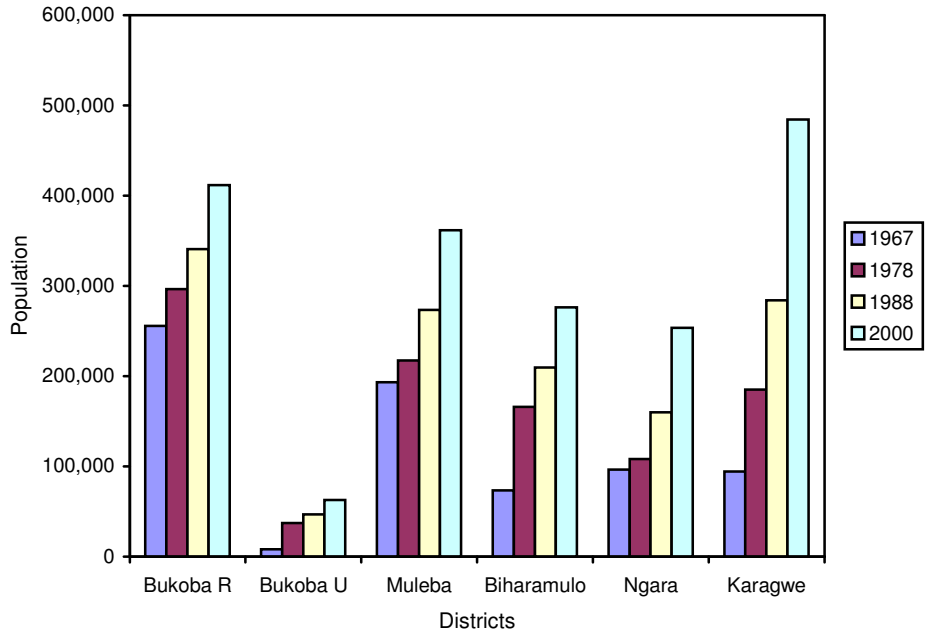

Figure 2: Population Distribution in Kagera Region (1967-2000)

Source of Data: URT (1998:5-9)

3.1.1 Bukoba District

Bukoba District is one of the six districts of Kagera Region. It is bordered by Uganda in the north, Lake Victoria waters of Mara Region in the east, Muleba District in the south and southeast and Karagwe District in the West. The district occupies a total area of 7,860 km^2, among which 5,450 sq.kms is dry land and 2330 sq.kms is covered by water. The

district has 6 Divisions, 41 wards and 161 villages. The divisions include Bugabo, Kyamutwara, Misenyi, Kiziba, Katerero, and Rubale.

3.1.1.1. Landscape Characteristics

Landscape characteristics of Bukoba District are related to structure. The landscape is dominated by series of parallel scarps running roughly from north southwards across Bukoba, Muleba and Biharamulo Districts. These scarps are steeply sloping with numerous rock outcrops and normally covered by grasslands. The plateaus surfaces are normally gently sloping westwards and often cultivated with bananas and coffee. The lowest points in between the scarps constitute broad and elongated drainage depressions, often swampy.

3.1.1.2. Land Use/Cover Types

Large proportion of Bukoba District is cultivated mainly with bananas and coffee. There are, however, some patches which are covered by natural vegetation which include forest and game reserves, and un-reclaimed swamps. Natural vegetation, mainly grassland is also found on steep and rocky scarps because such areas are unsuitable for cultivation due to steepness and dominance of rock outcrops.

3.1.1.3. Rainfall Erosivity

Bukoba District experiences a bi-modal rainfall pattern, March-May and October-November. Annual mean rainfall and temperature is 800-2000mm and 20^{o}C, respectively. Rainfall is higher along the lakeshore and decreases inland with distance from the lake and altitude. According to Moore (1979), the rainfall erosivity (kinetic energy) in Bokoba District is above 18,000 J/m^2/yr. This is among the highest in East Africa. The implications of such high levels of rainfall erosivity to soil erosion is immense.

3.1.1.4. Soil Erodibility

Dominant soil types are Haplic Ferralsols (about 78 percent), Ferralic Cambisols (about 15 percent), and Eutric Fluvisols (about 7 percent). Their relative abundance is shown in Figure 3. These soils are deep, highly weathered, well drained, and of low fertility. According to Figure 3, most of Bukoba District is covered by Haplic Ferralsols which according to FAO rating, these soils are higly erodible.

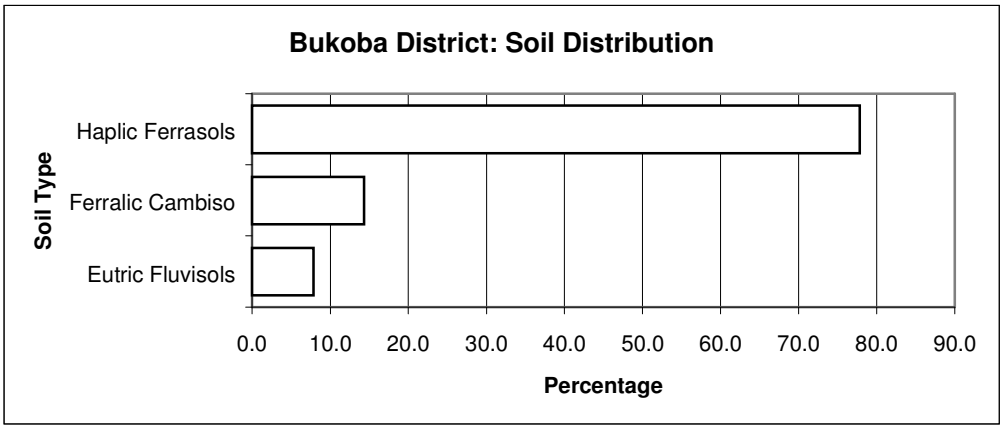

Figure 3: Soil types and their Relative Abundance in Bukoba District

The soils in the swamps are very variable in texture consisting mainly of sand, silt and clay (Kileo and Nyanga, 1996). These soils vary in their vulnerability to erosion depending on the differences in texture, chemical composition, and structure.

3.1.1.5. Human Population and Settlement Patterns

Bukoba District had a total population of 390,965 in 1988 and had an annual growth rate of 1.5 percent for the 1978/88 intercensual period. Population projection for year 2000 was 459,380. The population density is 63.1 persons/sq.km for Bukoba Rural District and 587 persons/sq.km for Bukoba Urban (URT, 1998). The average household size was 4.6 persons.

During the villagization programme, most settlements were not changed. There is high concentration of people on the escarpment and along the lakeshore where fishing is carried out. The high population concentration is also noticed in Kiziba, Bugabo, Kyamtwara, Misenyi, Rubale and parts of Katerero Divisions. The district is already densely populated and as such not so much immigration takes place into the district.

3.1.1.6. Major Economic Activities

The main economic activities in Bukoba District are farming, livestock keeping and fishing. Bukoba Rural and Urban Districts have 553,000 hectares of land area out of which 79,600 ha are under cultivation. Food crops grown in the district include bananas, beans, bambara nuts, maize and cassava. Cash crops include coffee, tea and sugarcane. The production of these crops is constrained by serious decline in soil fertility and very low level of investment in the farms. Bukoba District has favourable environmental conditions for livestock keeping (both traditional and exotic cattle). According to the 1997 livestock estimates, Bukoba Rural and Urban Districts had 114,718 cattle, 63,750 goats, 9,944 sheep and 503 pigs. The cattle density was estimated to be 16.4 cattle per sq.km.

Fishing is another important economic activity done in Bukoba District using traditional fishing gears. A significant increase in the number of persons and vessels involved in fishing activities has been observed since 1996. As mentioned earlier, fishing activities

are confined to the lakeshore. However, large numbers of fishmongers transport fish for sale inland.

3.1.1.8. Socio-economic Infrastructures/Services

Bukoba District has about 1,011 kilometres of road network of which 109 kilometres is trunk roads, 352 kilometres is by regional roads, about 329 kilometres is district roads, and 210 kilometres are feeder roads. With regards to the road surface, about 11 kilometres are tarmac, 542 kilometres are gravel and about 459 kilometres are of earth surface. The district has 3 hospitals, 7 Health Centres, 71 Dispensaries and 45 MCH Clinics. There are 17 pre-schools in Bukoba District with an enrolment capacity of 235 pupils. Also there are 229 primary schools with an enrolment of 68,154 pupils. About 98 percent of the population has been supplied with clean and safe water. Bukoba Rural and Urban Districts together have 121 Cooperative Societies of different types such as agricultural marketing, transport, consumer, fishing, and saving and credit. Extension services in the district suffer from common problems of lack of transport facilities and lack of funds for both extension work and operations.

3.1.2 Muleba District

Muleba District borders Bukoba Rural District in the North and North West, Lake Victoria waters of Mwanza Region in the East, Biharamulo District in the South and South West, and Karagwe District in the West. The district occupies an area of about 10,739 sq.kms of which 2,499 sq.kms is dry land and 8,240 sq.kms is water. The district is divided into 5 Divisions, 31 Wards and 116 villages.

3.1.2.1. Landscape Characteristics

Landscape characteristics of Muleba District are similar to those of Bukoba District. Likewise, the landscape is dominated by series of parallel scarps running roughly from north southwards. These scarps are steeply sloping with numerous rock outcrops and normally covered by grasslands. The plateaus surfaces are normally gently sloping westwards and often cultivated with bananas and coffee. The lowest points in between the scarps constitute broad and elongated drainage depressions often swampy.

3.1.2.2. Land Use/Cover types

Large proportion of Muleba District is cultivated mainly with bananas and coffee. There are, however, some patches which are covered by natural vegetation which include forest and game reserves, and un-reclaimed swamps. Natural vegetation, mainly grassland is also found on steep and rocky scarps because such areas are unsuitable for cultivation due to steepness and dominance of rock outcrops.

3.1.2.3. Rainfall Erosivity

The mean annual rainfall is 850-1100 mm and mean annual temperature is 20°C. The district experiences a bi-modal rainfall pattern. This are has an altitude ranging from 1,300 to 1,400 meters above sea level. According to Moore (1979), the rainfall erosivity (kinetic energy) in Muleba District is above 18,000 J/m^2/yr. This is among the highest in

East Africa. The implications of such high levels of rainfall erosivity to soil erosion is immense.

3.1.2.4. Soil Erodibility

Dominant soil types are Haplic Ferralsols (about 77 percent) and Ferralic Cambisols (13 percent). Their relative abundance is shown in Figure 4. These soils are deep, highly weathered, well drained, and of low fertility. Both main soil types occuring in Muleba district are highly erodible. The soils in the swamps are very variable in texture consisting mainly of sand, silt and clay (Kileo and Nyanga, 1996). These soils vary in their vulnerability to erosion depending on the differences in texture, chemical composition, and structure.

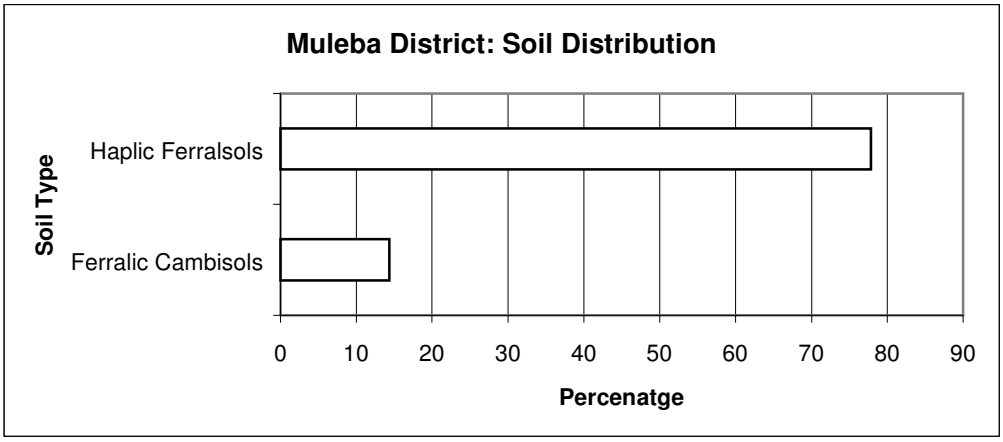

Figure 4: Soil types and their Relative Abundance in Muleba District.

3.1.2.5. Human Population and Settlement Patterns

The 1988 Population Census recorded a total population of 274,447 for Muleba District with average annual growth rate of 2.3 percent and an average household size of 4.9 persons. Population density was around 110 persons/sq.km. The population projections for 1998 and 2000 were 345,419 and 361,679people, respectively.

Like most districts in the region, dense settlements are found on good agricultural land. In Muleba District, the north-eastern part of the lakeshore is also densely settled. There is the tendency of people migrating from the western part of the district to the eastern part where fishing is one of the main income generating activity.

3.1.2.6. Major Economic Activities

The main economic activities in the district are farming, livestock keeping and fishing. The district has 83,737 hectares under cultivation which is just 34 percent of the total land area. The area under coffee/banana cultivation is 30,294 hectares and about 133 hectares are under tea production.

The farming systems, soils and rainfall patterns in Muleba District are similar to those of Bukoba District. The main food crops grown are bananas, beans, cassava, maize, bambara

nuts, sweet potatoes. Cash crops include coffee, cotton, and tea. Productivity of the area for these crops is low due to many factors such as declining soil fertility, poor agricultural practices applied, low level of investment in farming, etc.

Muleba District, like Bukoba Rural and Urban Districts as well as Karagwe District have favourable environmental conditions for keeping both traditional and exotic cattle. According the 1984 Livestock Census, the district had 51,056 cattle, 52,951 goats, 10,443 sheep and 154 pigs. Livestock diseases are a serious problem giving rise to poor livestock health and deaths to affected animals. East Coast Fever (ECF), Trypanosomiasis and Helminthiasis (intestinal worms) have been the most serious diseases.

Fishing is done along the lakeshores. Compared to the other two economic activities, fishing does not feature prominently in the district due to low income, low level of technology and low investment in the fisheries sub-sector.

3.1.2.7. Socio-Economic Infrastructures/Services

Muleba District has about 614 kilometres of road network out of which about 97 kilometres are trunk roads, 149 kilometres are regional roads, about 177 kilometres are district roads and 192 kilometres are feeder roads. With regards to road surface, about 278.5 kilometres is gravel and 336 kilometres is earth surface. The total district population served with clean and safe water is 29,436 which is about 11 percent of the total population. The rural population served with clean and safe water is 11,984 which is about 38 percent of the rural population. The number of villages served with clean and safe water is 32. The urban population with clean and safe water supplies is 10,300 which is about 61 percent of the urban population in the district. The district has 3 Hospital, 2 Health Centre, 31 Dispensaries and 23 MCH Clinics. There are 15 pre-schools in the district with an enrolment capacity of 635 pupils, 141 Primary schools with an enrolment of 42,389 pupils. The district has a total of 61 cooperative societies of which 44 are Agricultural Marketing, 11 Saving and Credit, 5 Livestock Cooperatives, and one other cooperative society. Extension services in the district suffer from common problems of lack of transport facilities and lack of funds for both extension work and operations.

3.1.3 Biharamulo District

Biharamulo District borders Karagwe and Muleba Districts in the North, Bukombe District in the South, and Geita District in the East, and Ngara and Kibondo Districts on the Western side. The district occupies an area of about 10,095 sq.kms of which 8,938 sq. kms is dry land and 1,157 sq.kms is water. The land area is about 31 percent of the regional land area. The district is located along a plateau which ranges between 1,150 and 1,650 meters above sea level. The district is divided into five divisions namely: Nyarubungo, Lusahunga, Chato, Buzirayombo, Bwanga and Nyamilembe. There are 22 wards and 117 registered villages in the district.

3.1.3.1. Landscape Characteristics

The landscape of Biharamulo district is similar to that of Bukoba District described above.

3.1.3.2. Land use/cover types

About 31 percent of the district land area is covered by protected forest and game reserves and hence natural vegetation is relatively abundant, particulary on the western part of the district. The presence of tsetse fly in the same areas has also contributed to limited human interference. The eastern part of the district has, however, experienced impact of human activities, particularly cultivation and livestock keeping. It is in this eastern part of the district (particularly, Chato, Buzirayombo, and Nyamirembe Wards) and around the refugee camps in Rusahunga Ward that soil erosion was observed to be significant.

3.1.3.3. Rainfall Erosivity

Climatic conditions in the district are similar to those of Bukoba Rural District, The temperatures range between 16°C and 26°C in the West and between 18°C and 28°C in the Eastern Lake Victoria shores. The mean annual rainfall is 700-1050mm. The district experiences a bi-modal rainfall pattern, March-May and October-November. Soil erosion is now a serious problem due to high rainfall regimes coupled with bad soil management in areas along the lakeshores.

Rainfall in the district varies with elevation, thus high altitude areas (ridges running northeast-southwest) receive relatively high rainfall compared to depressions in between. However, despite its low altitude, the area on the southeast of the district, around Bwanga, receive the highest rainfall ranging from 1,100 to 1,200 mm/yr. It is this area where rainfall erosive energy is high ranging from 10,000 to 18,000 J/m^2/yr. The rest of the district receives rainfall with lower energy ranging from 6,000 to 10,000 J/m^2/yr. This partly explains why the eastern part of the district is facing soil erosion problem.

3.1.3.4. Soil Erodibility

Dominant soil types in the district are Haplic Ferralsols, Ferralic Cambisols, Chromic Cambisols, and Dystric Calcisols. The four major soil types occuring in Biharamulo District are rated as highly erodible (See Figure 5).

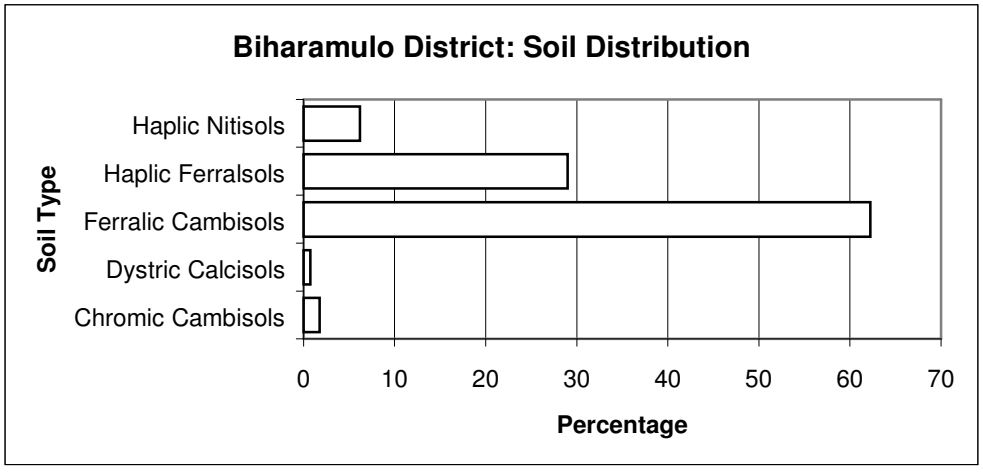

Figure 5: Soil types and their Relative Abundance in Biharamulo District.

3.1.3.5. Human Population and Settlement Patterns

The tribal mixture found in Biharamulo District reflects varying cultural behaviours and farming practices in relation to environmental protection. The 1988 population census recorded 209,524 people in Biharamulo District, half of them were women and another half were men. The growth rate of the district population during the 1978/88 intercensal period was 2.6 percent per annum. Given this growth rate, the district population was estimated to be 257,283 in 1996 and 285,103 in 2000 (Biharamulo District Council, 2000). Population density is estimated to be 23 persons per sq.km and the population projections for years 1998 and 2000 were 263,707 and 276,121 respectively.

Due to its location and environmental situation, Biharamulo District attracts many migrants from various parts of the country and neighbouring countries in search of arable land, pasture, and other income generating opportunities including lumbering, charcoal making, hunting, and bee keeping. Most of the immigrants are refugees from Rwanda and Burundi. Migration into Biharamulo District started way back in 1960s. Migration flows still continue today although some people are currently migrating away from the eastern parts of the district which are bare and affected by erosion hazards. Often, the migrants move to the western parts of the district to open up new farms and settlements. This is due to increased population density in the eastern parts of the district.

Like in most districts of Kagera Region, areas with good agricultural potentials (e.g. Nyarubungo, Nyamirembe, Buzirayombo Kasozibakaya and Bwanga) are densely populated. There is also a high concentration of livestock especially in Nyamirembe and Buzirayombo areas. In addition, these areas are characterized by high livestock density especially in Nyamirembe and Buzirayombo Divisions which have good pasture areas and adequate rainfall

3.1.3.6. Major Economic Activities

The main economic activities in the district are farming, fishing and livestock keeping. Beekeeping and lumbering are also practiced though at a minimal scale. Although the district has 893,800 hectares of land, only 27,400 hectares (about 3 percent) is under cultivation.

Biharamulo District is divided into four agricultural zones, namely: the Lake, Eastern, Western and Southern Zones. The Lake zone covers Chato, Bukome, Nyamirembe, Muganza and Kigongo Wards. The soils in this zone are sandy and soil fertility is low. The rainfall is also low (about 700 mm). The main crops grown in the Lake Zone include cotton, maize, cassava, paddy and sweet potatoes. The main economic activities are farming, and livestock keeping. Fishing is mainly done in the Lake zone along the shoreline.

The Eastern Zone covers Bwanga, Buziku, Bwera, Makurugusi, Buseresere, Katende, Ilemera, Ichwankima and Kachwamba Wards. The rainfall ranges between 700-1000 mm per annum and the main economic activities is farming. The crops grown include cotton, maize, cassava, and sweet potatoes. Other crops are paddy and sorghum.

The Western Zone lies between 1250-1700 meters above sea level. It covers Biharamulo Urban, Nyarubungo, Runazi, Nyabusozi, and Nyamigogo Wards. The rainfall ranges between 800-1,000 mm. The soils are reddish and soft and there are soils that are mixed with gravels. Mixed cropping is practiced here whereby banana, beans, sorghum and maize are grown as food crops and coffee as a cash crop.

The Southern Zone covers Kalenge, Lusahunga, and parts of Nyakahura Wards. The altitude ranges between 1100-1400 meters above sea level. This zone is dominated by clay soils which have low fertility. Crops grown include sorghum, cassava, maize, beans, sweet potatoes, and groundnuts. Other activities include lumbering and beekeeping.

According to the 1984 Livestock Census, the district had 78,337 goats, 9283 sheep and 102 pigs. The estimated cattle population in the district for 1997 was 48,163.

3.1.3.7. Socio-Economic Infrastructures/Services

Biharamulo District has a total length of road network of 833 kilometres out of which 314 are trunk roads, sbout 88 kilometres regional roads, 202 kilometres are district roads and 530 are feeder roads. With regards to road surface, about 112 kilometres is tarmac, about 290 kilometres is gravel and 432 kilometres is covered by earth surface.

About 51 percent of the rural population is served with clean and safe water and 51 percent of the urban population is served with clean and safe water. The district has one Hospital, one Health Centre, 30 Dispensaries and 22 MCH Clinics. Biharamulo District has 9 Pre-Schools with an enrolment of 597 pupils, 109 Primary Schools with an enrolment capacity of 31,000 pupils. The district has 35 different types of cooperatives including Agricultural Marketing, Saving and Credit, and Livestock Cooperatives. Extension services in the district suffer from common problems of lack of transport facilities and lack of funds for both extension work and operations.

3.1.4 Karagwe District

Karagwe District borders Uganda in the North and Rwanda in the West. Kagera River forms the boundary between Karagwe and Rwanda. Other neighbours of Karagwe District are Ngara and Biharamulo Districts in the South, and Muleba and Bukoba Districts in the East. The district occupies a total area of 7,716 sq.kms, out of this, 7,558 sq kms is dry land and 158 sq.kms is water. These are 26 percent and 1 percent of Kagera Region's total land and water areas respectively. Administratively, the district is divided into four divisions namely, Kaisho/Murongo, Bugene/Nyaishozi, Katuntu/Mabira, and Nyabiyonza. There are 28 wards and about 101 registered villages.

3.1.4.1. Landscape Characteristics

Karagwe District is characterized by mountain ranges that are separated by valley bottoms and wetlands. The altitude ranges between 1,500 and 1,450 meters above sea level.

3.1.4.2. Land Use/Cover Types

Karagwe District has about 93,000 hectares of forests under conservation and 120,000 hectares of bush, swamps and rivers. However, deforestation and bushfires are common practices in the districts. Although the rate of deforestation is comparatively high, tree planting is not very common. Most of the households who practice tree planting prefer to plant various species of eucalyptus. UNHCR has contracted an NGO to plant trees in the areas that were affected by refugees. The NGO on its part has established seedlots and seedlings are being distributed to the villagers for planting in their farms.

Major part of the district is cultivated and the remaining are mostly the protected areas (forest and game reserves) and ranches. There are also some patches left uncultivated because they are situated on very steep slopes and some are swamps. Most of the cultivated areas are on hill slopes, thus land mismanagement may lead to severe land degradation through soil erosion.

3.1.4.3. Rainfall Erosivity

The district has a tropical climate with an annual average temperature of 26^{o} C. It experiences a bi-modal rainfall patterns, March-May and October-November. Rainfall distribution is bi-modal with peak rains from September to December and from March to May. Most part of the district receives rainfall between 800 and 1000 mm/yr, and erosive energy of the rain ranges between 6,000 and 10,000 J/m^2/yr. The high ridges get over 1,000 mm/yr of rains. These high areas are also the steepest and vulnerable to soil erosion, particularly where soil conservation measures are not practiced.

3.1.4.4. Soil Erodibility

The dominant soil types in Karagwe District are Leptosols (about 90 percent), Fluvic Histosols (about 8 percent), and Eutric Fluvisols (2 percent). Most of the district is covered by Leptosols, which is rated to be very highly vulnerable to erosion. The greater part of Kagera District, therefore may be considered to be very highly vulnerable to erosion (see Figure 6).

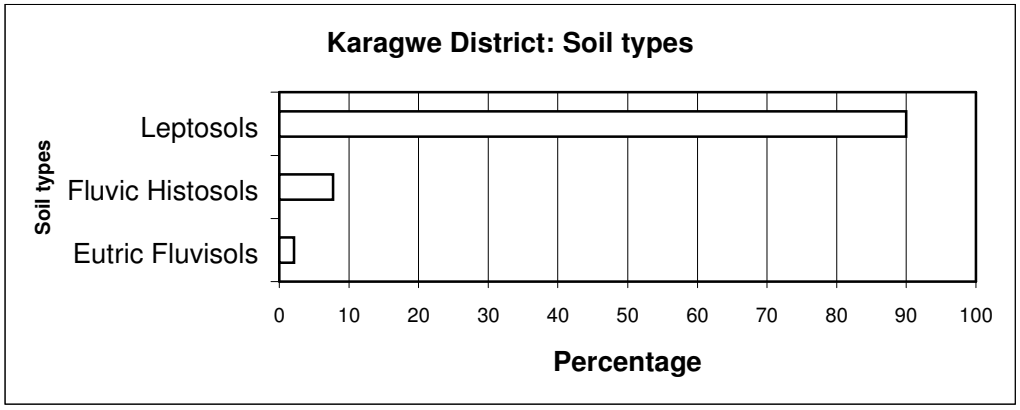

Figure 6: Soil types and their Relative Abundance in Karagwe District.

3.1.4.5. Human Population and Settlement Patterns

The population of Karagwe District has increased by about 613 percent from 94,407 people in 1967 to 292,589 people in 1988. Population projections for years 1998 and 2000 were 263,707 and 276,121 respectively. Using the annual population growth rate of 2.7 percent (1978/88), the current population is estimated to be around 391,177. Karagwe District also received about 150,000 Rwandan refugees between 1994 and 1996 as illustrated in Table 3.

Table 3:Distribution of Refugees by Camps in Karagwe District (1994-1996)

Refugee Camps	**Number of Refugees**	**Percent of Total**
Kyabalisa 1	44,313	35.3
Kyabalisa 2	32,700	26.1
Kagenyi	15,762	12.6
Rubwera	23,745	18.9
Omukariro	7,954	6.3
Total	125,473	100.0

Source: Karagwe District Council (1997)

The negatives impacts of the refugee influx in Karagwe District include massive deforestation in areas surrounding the camps, vandalization of social service facilities like school desks, increased food insecurity and commodity prices, social insecurity, spread of HIV/AIDS, and the over-stretch of the existing social service facilities to meet the demands of the refugee population. Apart from the 1994-96 Rwandese Refugee wave[1], there are other immigrants entering the district from Muleba and Bukoba districts in search of agricultural land. Migrants from Uganda also enter the district mostly in search of pasture. Some of the former refugee camp sites like Kigenyi, Rubwera and Omukariro have been settled by local communities, mostly the pastoralists.

Currently, there is no evidence of out-migration from Karagwe District. However, intra-district movements occurs especially from areas with poor land quality due to over use and lack of appropriate conservation measures. A lot of people are migrating from Muleba and Bukoba Districts into Karagwe District in search of agricultural land and pasture. There are also livestock keepers from the neighbouring countries of Uganda and Rwanda moving into Karagwe District in search of pasture. These are causing land pressure or land shortage in the district.

Areas that have good soils and adequate amount of rainfall have been densely settled. These areas include Kituntu, Kaisho, Nkwenda, Bugomola and Bugene wards. There is already a serious shortage of land in areas such as Ihembe, Ndama, Kituntu, Bugeni and Kashanda Wards. These are the same areas keeping large herds of cattle. Livestock from Uganda and Rwanda come to graze in the area.

3.1.5.6. Major Economic Activities

[1] All the refugees have been repatriated and the new ones who are coming are moved to the existing camps in Ngara District.

The main economic activities carried in the district are farming and livestock keeping. Fishing and mining are insignificant economic activities carried out in the district. Karagwe District has a total land area of 699,300 hectares Land area under cultivation is 201,000 hectares. The main food crops grown include: Bananas, beans, cassava, maize and sorghum. The main cash crop grown is coffee. Customary land tenure systems dominate in the district. Land is normally passed from one generation to another through inheritance. Village governments also preserve some land for communal use and sometimes for distribution to landless people and new comers.

Generally, there are three main farming systems in Karagwe. These are the Kibanja, Kikamba and Rweya systems. The *Kibanja system* is comprised of a banana plot that is normally intercropped with coffee, beans, maize and many other annual crops and tree species. The *Kikamba system* is comprised of plots that are sometimes left fallow and are used for annual crops. Most Kikambas are found in the peripheries of the Kibanjas. The soils in the Kikamba farms are of medium quality and are used to grow annual crops like sweet potatoes, cassava, maize, beans and groundnuts. The *Rweya system* is found in areas of poor quality soils and is mostly used for tree planting, provision of mulching grasses and fodder.

The main land use in Karagwe District is farming. About 31 percent of the total land area is under continuous coffee/banana cultivation and other annual crops. Wooded and open grassland occupy about 52 percent of the landmass and closed forests cover only 2 percent. Other land uses include seasonal swamps (13 percent) and water bodies (2 percent). About 90 percent of the households in Karagwe District are engaged in agriculture. Upland, wetland, siliviculture type of farming are practiced. The main crops grown in Karagwe include coffee, banana, maize, beans and cassava. Other crops are sunflower, groundnuts and millet. Horticulture is practiced along valley bottoms.

Table 4 summarizes the trends in production of various crops between 1990 and 1995. Though the district economy is dependent on agricultural production, the volume of agricultural produce (especially coffee) has been declining. The observed declining trends in production can be explained by the declining use of agricultural inputs. In recent years, very few farmers have managed to apply agricultural inputs (particularly fertilizers and pesticides) in their farms. The decline in the use of inputs is mainly a function of high prices attributed to the removal of subsidies on agricultural inputs and poor performance of cooperatives in relation to marketing and supply of agricultural inputs. As a coping strategy to this situation, the use of farmyard manure and the mulching system have been adopted especially in the Kibanja plots.

Table 4: Production of Major Crops in Karagwe District ('000 Metric Tons)

Year	Banana	Coffee	Beans	Maize
1990	190.5	9.6	22.4	20.0
1991	395.0	9.1	18.0	28.0
1992	396.0	11.8	14.5	28.0
1993	396.0	5.2	19.0	25.0
1994	375.0	6.8	32.4	22.6
1995	651.0	4.9	38.0	26.0

Source: URT (1998), Karagwe District Council (1997)

Karagwe District has a favorable environment for raising both exotic and traditional cattle. There are four distinct livestock production systems in Karagwe District. First, *indigenous cattle* are kept on communal land set aside by village government. The second system is the *semi-nomadic* system whereby large herds of cattle are grazed on communal land and move around depending on availability of pasture and water. The third system comprises of *smallholder dairy cattle* farmers who practice zero grazing. Lastly is the *large-scale ranching* system where beef cattle are reared in large numbers. Currently there are five ranches in Karagwe District owned by the National Ranching Corporation (NARCO).

According to the 1984 Livestock Census, the district had 127,970 cattle, 58,895 goats, 17,667 sheep, and 554 pigs. Kituntu/Mabira is one of the divisions famous for livestock keeping. The district is estimated to have about 294,262 cattle, 58,895 goats, 17,667 sheep and about 554 pigs (URT, 1998). Efforts have been made to minimize the shortage of grazing areas and land use conflicts by alienating some areas specifically for grazing purposes as summarized in Table 5.

Table 5: Distribution of Grazing Areas by Wards and Division

Divisions	Wards	Grazing Areas
Kituntu/ Mabira	Mabira	1. Ruhita-Kaatabe
	Igurwa	2. Irugwa
	Kituntu	3. Kahundwe
		4. Champesha
	Kihanga	5. Kitanda
Kaisho/ Murongo	Kaisho	6. Siirna
	Muringo	7. Ibanda 1
Bugene/ Nyaishozi	Nyaishozi	8. Ruhita-Chenjubu
		9. Nyakararo
	Bugene	10. Kakashombwa
		11. Kashanda
		12. Chonyonyo
Nyabionza	Nyabionza	13. Ngembe
		14. Kanyamagana
		15. Kajunju

Source: Karagwe District Council (1997)

The District Council has enacted a by-law that controls the use of these grazing areas. The grazing areas are managed jointly by the surrounding local communities. However, there is evidence of some encroachment of farming activities in these grazing areas (e.g. in Siina). Lack of reliable markets for milk and milk products both within the district and outside is the main problem affecting the livestock sector in Karagwe District.

Other economic activities include fishing and mining. However, fishing is not a major economic activity in Karagwe District. Although it is carried out on a small-scale basis in rivers and lakes, its contribution to the household

and district economy is negligible. With regards to mining, there are some activities carried out in the district though at a small-scale level. Tin mining is conducted at Kyerwa. However, existing records show a declining trend in the amount of tin bought by STAMICO from 20,629 kilograms in 1990 to only 3,259 kilograms in 1994 (Karagwe District Council, 1997).

3.1.4.7. Socio-economic Infrastructures/Services

District has the total length of 719 kilometres of road network of which 284 kilometres are regional roads, 248 kilometres are district roads, and about 187 kilometres are feeder roads. About 409 kilometres of road is gravel and 311 kilometres is of earth surface. The district has 21 pre-schools with a total enrolment of 514 pupils, and 133 primary schools with an enrolment of 43,326 pupils. The district also has 3 Hospitals, 3 Health Centres, 40 Dispensaries and 31 MCH Clinics. Karagwe has the following functioning rural water supplies facilities: 12 gravity schemes, one pumped scheme, and 45 shallow wells. Karagwe The district has 74 Cooperative Societies constituting of Agricultural Marketing, Saving and Credit, Consumer and Livestock Cooperatives Societies. Extension services in the district suffer from common problems of lack of transport facilities and lack of funds for both extension work and operations.

3.1.5 Ngara District

Ngara District borders by Karagwe District and Rwanda in the north, Biharamulo District in the east, Kigoma Region and Burundi in the south and Burundi in the west. The district occupies 4,428 sq. kms and is divided into 4 Divisions, 17 Wards, and 70 Villages.

3.1.5.1. Landscape Characteristics

The district falls in a series of dissected plateaus at different altitude levels. Subsequent erosion and dissection has evolved into hills, ridges and valleys. There are three altitude classes – high level (1,650 m), intermediate level (1,500 and 1,650 m) and low level (less than 1,500 m). These are called the Bugufi highlands, the Kasulo and the Ruvubu, Kirushya and Murusagamba, respectively. Within these major landscape units, there are various physiographic units namely, hills and scarps, dissected peneplains, plateaus, footslopes, swamps, flood plains, river terraces and minor valleys (ETC East Africa, 1997). Extension services in the district suffer from common problems of lack of transport facilities and lack of funds for both extension work and operations.

3.1.5.2. Land Use/Cover Types

The natural vegetation types in the district can be categorised as forest, wooded grasslands, bushed grasslands, grasslands and swampy vegetation. Grasslands are characteristic of areas with shallow soils such as scarps and hilltops. Forest is restricted to some parts of the Ruvuvu River and the northern part of the district which falls under the Bugiri Game Reserve. Bushed and wooded grassland are found all over the district. However, in many places the natural vegetation has been cleared for various purposes. Similarly, the Bugiri Game Reserve in the north is undergoing degradation, mainly

through encroachment through tree cutting, burning, cultivation and illegal hunting (ETC East Africa, 1997).

3.1.5.3. Rainfall Erosivity

Rainfall is bimodal with peaks in March/April and a less pronounced one in November/December. The rainfall decreases from northwest (about 1,300 mm) to southeast (about 800 mm and less). Generally, the rainfall erosive energy is between 6,000 to 10,000 $J/m^2/yr$.

3.1.5.4. Soil Erodibility

Soils distribution in Ngara district related is to landform units. However, the most extensive soil unit is Haplic Ferralsols which are highly vulnerable to erosion. Ridges and pleaus have well drained, medium to strongly acid, colour ranging from dark reddish brown sandy loams to sand clay loams. Soils on hilltops or scarps are generally shallow (about 30 cm), well drained, colour varying from very dark grey to dark reddish brown. These soils are normally not cultivated owing to steepness of slopes, stonnines, shallowness, and erosional hazard. Soils on river terraces/valleys and in swamps have textures varying from clay to almost pure sand depending on physiographic position.

3.1.5.5. Human Population and Settlement Patterns

The district had a total population of 158,658 people according to 1988 census. The average household size was 4.5 persons and the population density was 35.8 persons per sq km. Population projection for year 2000 was 253,345 with the growth rate of 3.9 percent per year.

Settlements have been established in fertile parts of the district and which receive adequate rainfall with good pastures. There is high concentration of people in and around Lukole Refugee Camp and also around the former BENACO Refugee Camp. The population in other parts of the district lives in scattered villages. There has been an influx of refugees from Burundi some of whom came in the country illegally. There are other migrants who came from neighbouring districts and regions seeking for agricultural and pasture land and also who came to provide services to the refugees in Bukole and BENACO Refugee Camps.

3.1.5.6. Major Economic Activities

Important economic activities in the district include farming and livestock keeping. Ngara District has an estimated land area of 442,800 hectares out of which 72,000 hectares is under cultivation. Food crops grown in the district include bananas, beans, maize, sorghum and cassava. The main cash crop grown is coffee. According to 1984 livestock census there were 18,294 cattle, 90,367 goats, 6,463 sheep and 749 pigs. However, the estimated number of cattle by 1997 was 18,925.

3.1.5.7. Socio-economic Infrastructures/Services

Ngara District has the total length 774 kilometres of road network, of which 87 kilometres are trunk roads, 262 kilometres are regional road, about 222 kilometres are district roads, and 262 kilometres are feeder roads. About 90 kilometres of the roads is tarmac, 262 kilometres is gravel roads, and 422 kilometres is earth roads. The district has 3 pre-schools with an enrolment of 222 pupils, and 77 primary schools with an enrolment of 22,200 pupils. The district has 2 Hospitals, 2 Health Centres, 29 Dispensaries and 25 MCH Clinics. Rural water supplies in the district has the following functioning water installations: 7 gravity schemes, 3 pumped schemes and 163 hand pumped shallow wells. There are 5 cooperatives in the district which includes Agricultural Marketing, Saving and Credit, Consumer and two Livestock Cooperatives. Extension services in the district suffer from common problems of lack of transport facilities and lack of funds for both extension work and operations.

3.2 Mwanza Region

3.2.1 Geita District

Geita district is bordered by Sengerema District in the North East, Kagera Region in the West and North West, Misungwi District in the South East and Shinyanga Region in the South. The district occupies a total area of 7,825 sq.km out of which 6,775 sq.km is dry land and 1,050 sq.km is water. Geita has 7 Divisions, 33 Wards and 185 Villages.

3.2.1.1. Landscape characteristics

Landscape of Geita District is gently undulating with isolated hills (inselbergs). The hills are steep and rocky, while the pediments are gently sloping towards the drainage depressions. These pediments are vulnerable to erosion, particularly where vegetation cover has been removed through cultivation or overgrazing.

3.2.1.2. Land use/cover types

Geita District is relatively vegetated compared to the area of Sukumaland east of the line of Smith Sound. Woodlands and bushlands are still found particularly in forest reserves on hills and pediment slopes. Where not cultivated, the extensive network of depressions that occur in the area are often covered with grass or various forms of woody vegetation. These depressions constitute principal grazing areas, particularly during the dry season. These depressions often act as sediment traps. Elsewhere is cultivated or heavily grazed.

3.2.1.3. Rainfall Erosivity

Geita district has reliable rainfall and on the high side. It has two rainy seasons per year. Most of Geita District receives between 800 and 1000 mm of rainfall per year and rainfall erosive energy ranges between 6,000 and 10,000 J/m^2/yr. However, northern part of the district (around the lake shore) receives between 1000 and 1200 mm per year of rainfall, and the rainfall erosive energy is between 10,000 to 14,000 J/ m^2/yr.

3.2.1.4. Soil Erodibility

Figure 7 shows the relative coverage of the most commonly found soils in Geita district, namely Ferralic Cambisols, Chromic Cambisols, Eutric Verisols, Dystric Calcisols, and

Haplic and Rhodic Farralsols. All these soils are ranked as highly vulnerable, except Eutric Vertisols.

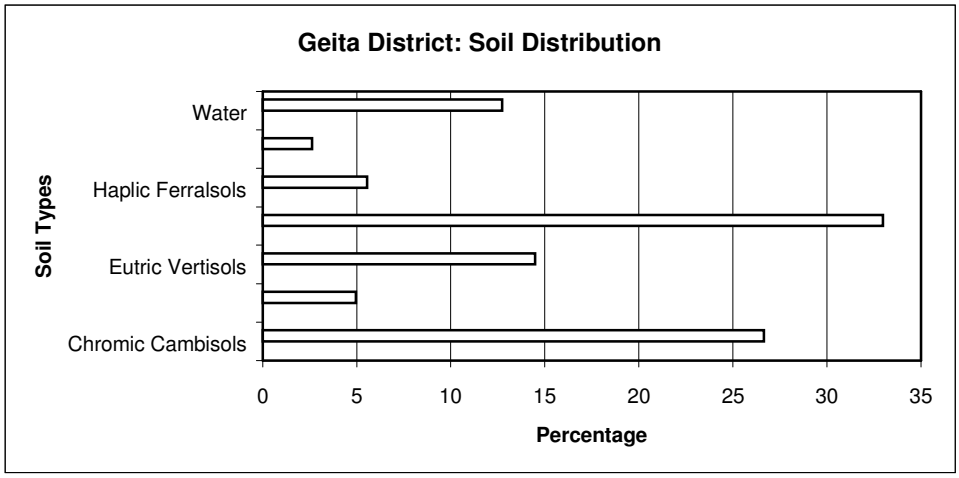

Figure 7: Soil types and their Relative Abundance in Geita District.

3.1.2.5. Human Population and Settlement Patterns

According to 1988 census the population was 439,191 with the growth rate of 3.6 percent per annum. The population was projected to be 719,565 people by the year 2000. Population density for 1995 was estimated to be 86 people per sq. km. The average household size for 1988 was 6.5 persons. Areas that have great agricultural potential attract migrants and are currently densely settled. Similarly, areas along the lakeshores where fishing is the main activity and those areas with gold mining activities are also densely populated. There is a significant movement of people into the Geita District especially after the reestablishment of gold mining activities. Evidence of the reactivated growth is seen in Geita town which was almost dormant for many years. The implications of such rapid migration is reflected in the increased burden on the available social services and the demand for products from natural resources like firewood and charcoal.

3.1.2.6. Major Economic Activities

The major economic activities in Geita District are farming, livestock keeping, fishing and mining. The district has about 206,000 hectares of arable land and 252,000 hectares of grazing areas. The food crops grown in the district include maize, cassava, sweet potatoes and bananas. The cash crops include cotton and paddy. Cotton is mainly grown in Nyanhwale and Msalala Divisions, Kaseme and Katoro Wards, as well as Buharahara Village.

Livestock keeping is concentrated in Msalala and Nyanhwale Divisions where serious overgrazing occurs. According to the 1984 Livestock Census, the district had a total of 272,248 cattle, 144,725 goats 32,251 sheep and 897 donkeys. Watering points in these areas are not evenly distributed as a result there is severe degradation along cattle routes and around watering points.

Fishing is done along the lakeshore particularly in Bugando and Chigunga Divisions and in Nyang'wilolelwa, and Nkome Villages. Fish processing is done by sun drying or fish smoking using firewood.

Mining activities take place is several parts of the district. There are several large-scale gold mining in Geita District. These include the Ashanti Gold Mining which operate around Geita town and Buckreef Gold Mine. Artisanal mining by small-scale miners is mainly done at Nyarugusu, Nyamtondo, Lwamgasa, Nyakagwe, and Nyamwilima. Serious deforestation and land degradation were observed especially around mining sites.

3.1.2.7. Socio-Economic Infrastructures/Services

The total length of the Geita District road network is 1,517 kilometres out of which 61 kilometres are trunk roads, 383 kilometres are regional roads, 500 kilometres are district roads, and 573 kilometres are feeder roads. About 256 kilometres of the road network is of gravel surface and 1261 kilometres is covered with earth surface. Earth surface roads passing through sandy soils in rolling or hilly terrain are subject to soil erosion during the rainy season. In the urban areas, about 10,620 people are served with clean and safe water. This is just 45 percent of the total urban population. In the rural areas, about 74 percent of the total number of the village are served with clean and safe water. Though the proportion rural villages seem to be high, there exists variations at village levels where some sub-villages have to go more than five kilometres in search for water for domestic use and even greater distances for watering the livestock. The proportion of the rural population in the district served with clean and safe water service for domestic use is about 34 percent (around 189,932 people).

There is 1 Hospital in the district, 5 Rural Health Centres, 55 Dispensaries, and 45 MCH Clinics. These facilities are not enough to satisfy demand of the health services in the districts. The 1997 district records show that there were 206 primary schools with an enrolment capacity of 68,624 pupils. There are 9 Secondary Schools and one Vocational Training Centre. Major constraints of the extension services in the district include lack of transport facilities and lack of funds for both extension work and operations.

3.2.2 Kwimba District

Kwimba District is bordered by Magu District in the north, Shinyanga Region in the East and Southern side, and Misungwi District in the North Western part. The district has a total land area of 3,903 sq.kms. It district has 5 Divisions, 25 Wards and 111 Villages.

3.2.2.1. Landscape characteristics

Landscape of Kwimba district is characterised by flat to gently undulating plains, occasionally with isolated inselbergs and pediment slopes leading to flat bottomed drainage depressions (mbugas).

3.2.2.2. Land use/cover types

Land use/cover in Kwimba district is human induced and the general area is often referred to as the the cultivation steppe on account of its lack of trees. However, there are few

pockets of natural vegetation (*Ngitiri*) mainly bushes which are managed communally or privately. Though the district has 1389 hectares of forest reserve, the rest of the district has scanty vegetation cover except for few areas with scattered shrubs and isolated trees. Lack of protective cover exposes the area to soil erosion agents.

The main land use types are cultivation and grazing. The district has about 350,000 hectares of grazing land and about 197,000 hectares of arable land. However, the size of the pasture land has increasingly been reduced especially due to agricultural expansion into the pasture areas.

3.2.2.3. Rainfall Erosivity

The district has a tropical dry climate which gets very hot towards the end of the dry season. It has two well defined seasons, the dry season and the rainy season. Rainfall is often scanty and unreliable. The mean annual rainfall is around 850 mm. Even the onset of the rain season is unpredictable, especially due to changes in the environmental and climatic conditions in the district. Such climatic changes have a notable influence on the availability of water especially in the dry season. Kwimba district receives around 850 mm per year and rainfall erosivity ranges from 6,000 to 10,000 J/m^2/yr.

3.2.2.4. Soil Erodibility

Four different soil types are distinguished in Kwimba district, namely Rhodic Ferralsols (locally known as *Luseni*), Eutric Planosols (locally known as *Itogolo*), Ferralic Cambisols, and Eutric Verisols (locally known as *Mbuga*). Rhodic Ferralsols are rated to be moderately erodible while Eutric Planosols and Ferralic Cambisols are rated to be highly erodible (Figure 8).

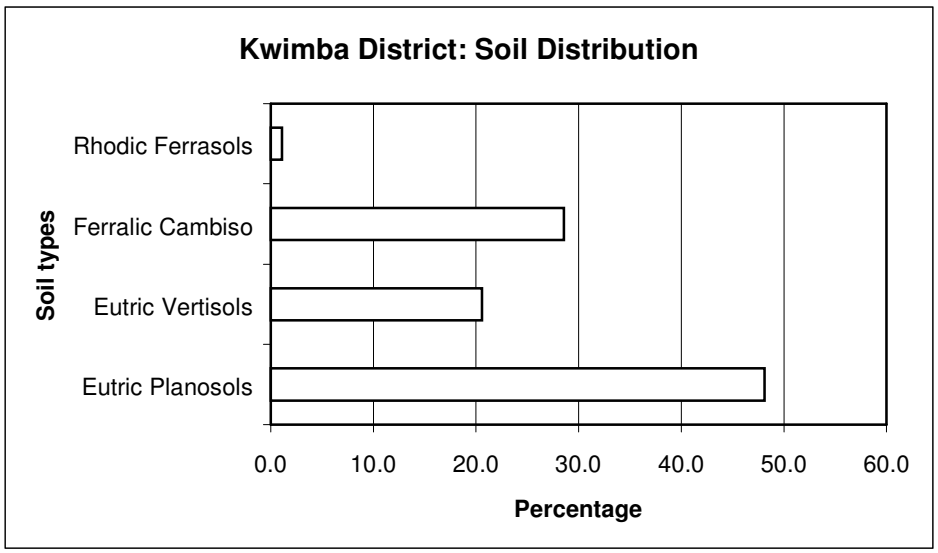

Figure 8: Soil types and their Relative Abundance in Kwimba District.

3.2.2.5. Human Population and Settlement Patterns

According to the 1988 Population Census, Kwimba District had 427,726 people with a growth rate of 2.7 percent (including Misungwi District). Population density estimates was 81 persons per sq.km in 1995. The average household size in 1988 was 6.7 persons per household. Since the introduction of villagization programme, settlements have been established in areas good for agriculture. Settlements were clustered into registered villages located along transport networks. However, this settlement structure has collapsed especially after the relaxation of the Ujamaa Policy administrative setups. Settlement patterns have dispersed once again with new sub-villages been created to enable people to live closer to their farms. There is a tendency of people to migrate out of the district in search of pasture and arable land elsewhere. However, significant in-migration has been observed especially in villages that practice mining activities.

3.2.2.6. Major Economic Activities

The main economic activities of Kwimba District are farming and livestock keeping. Some mining activities and trading are also done though to a limited extent. Food crops grown in the district include maize, paddy, sorghum, bulrush millet, cassava, sweet potatoes and legumes. Cotton is the main cash crop although its importance has been diminishing in recent years. Thus, both the total production and average yield per hectare of cotton have been declining due to poor husbandry practices, non-utilization of agricultural inputs, and delays in payment of cotton farmers. The latter factor has caused some farmers to quit cotton production. As a result, rice production has been increasing over years and is used both as a food and cash crop.

According to the 1984 Livestock Census, Kwimba (including Misungwi Districts) had 506,874 cattle, 166,445 goats, 120,589 sheep, and 4,416 donkeys (URT, 1997). The type of cattle kept in the district is predominantly shorthorn Tanzania Zebu. Livestock keepers use free range grazing systems on communal land leading to overgrazing. Recent observations show an increase in land use conflicts especially between cultivation and livestock grazing. This situation has been accelerated by the rapid expansion of farming activities into the traditional grazing areas (the *mbugas*) basically due to population pressure. The *mbuga* soils were in the past considered unsuitable for agricultural activities. Todate, most of the agricultural activities are found in these areas. Milk and meat production is low.

3.2.2.7. Socio-Economic Infrastructures/Services

Kwimba District has 1346 kilometres of road network, out of which 113 kilometres are trunk roads, 361 kilometres regional roads, 364 kilometres district roads, and 508 kilometres feeder roads. With regards to the road surface, 373 kilometres of the roads has gravel surface and 973 kilometres have earth surface. Few kilometres of the trunk roads are tarmac on the Mwanza-Shinyanga road.

The proportion coverage for the provision of clean and safe water for the urban population is about 57 percent (10,732 people). In the rural areas, about 81 percent of the rural villages (89 villages) are served with clean and safe water. These villages accommodate about 45 percent (123,082) of the rural population.

The district has 2 Hospitals, 2 Rural Health Centres, 29 Dispensaries, and 31 MCH Clinics. There are 220 Primary Schools with an enrolment of 72,387 pupils. The district

has 7 Secondary Schools. Kwimba District has a total of 67 cooperative societies. These include Agricultural Marketing, Saving and Credit, Industrial, Building, Fishing, and Transport societies. Major constraints of the extension services in the district include lack of transport facilities and lack of funds for both extension work and operations.

3.2.3 Magu District

Magu District is bordered by Ukerewe District and Mara Region in the north and north east, Shinyanga Region, Kwimba District in the South and Mwanza District in the west. The district occupies a total area of 4,795 sq.km out of this 3,070 sq.kms is dry land and 1725 sq.kms is covered by water. The district forms about 14 percent of the total regional area. The district is divided into 6 Divisions, 27 Wards and 116 villages.

3.2.3.1. Landscape characteristics

The district is characterised by gently undulating plains with occasional rocky hills/ridges surrounded by pediments leading down to depressions (mbugas).

3.2.3.2. Land Use/Cover types

Land cover/use types in Magu district show influence of human activities, particularly, cultivation and grazing. As a result, most of the district has been stripped of its natural vegetation, except on the less accessible rocky hills and ridges and individually and communally owned traditional woodlots (*ngitiri*).

3.2.3.3. Rainfall Erosivity

Magu district has low and unreliable rainfall. It has a typical tropical dry climate which gets hot towards the end of the dry season. It has a dry and rain season. The district receives between 800 and 1,000 mm of rain per year and rainfall erosivity ranges from 6,000 to 10,000 $J/m^2/yr$.

3.2.3.4. Soil Erodibility

The dominating soil type in Magu District is Eutric Planosols (about 78 percent). Other soil types are; Eutric Vertisols, Mollic Solonetz, Chromic Cambisols and Haplic Ferralsols (see Figure 9). Since Eutric Planosols are rated as highly vulnerable to erosion, most of Magu district may therefore be considered to be potentially at risk of soil erosion.

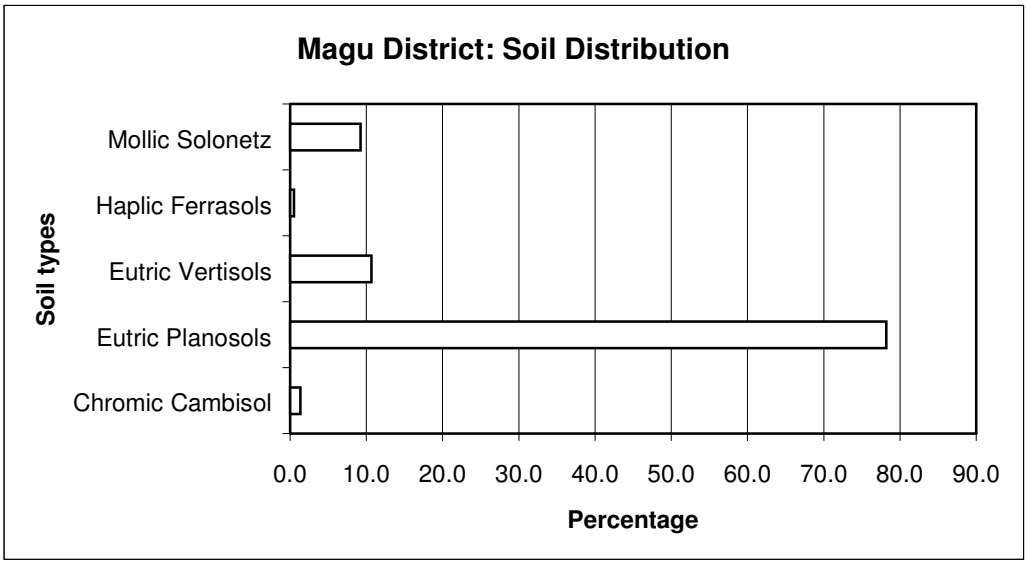

Figure 9: Soil types and their Relative Abundance in Magu District.

3.2.3.5. Human Population and Settlement Patterns

According to the 1988 census, the population of Magu District was 310,918 with a growth rate of 1.8 per annum and an average household size of 6.4 persons. Population projection for the year 2000 was 439,434. The population density in the district was estimated to be 117 persons per sq.km in 1995. Settlements have been established in areas with good pasture, along the lakeshore, and in agriculture potential areas.

3.2.3.6. Major Economic Activities

The major economic activities of Magu District are farming, livestock keeping, and fishing. The main food crops grown include sorghum, bulrush millet, maize and paddy. The cash crops are cotton and paddy. Crop failures particularly maize are very frequent. According to 1984 livestock census the district had 294,574 cattle, 96,519 goats, 80,125 sheep and 375 donkeys.

3.2.3.7. Socio-economic Infrastructures/Services

The total length of road network is 1236 kilometres out of 128 kilometres are trunk roads, 165 kilometres are regional roads, 393 kilometres are district roads, and 550 kilometres are feeder roads. With regards to the road surface, there are about 120 kilometres of the roads is tarmac, 125 kilometres is gravel, 991 kilometres is covered by earth surface.

The number of people served by clean and safe water facilities in the urban area is 14,119 which is 48 percent of the total population of the urban area. The number of villages served with clean and safe water facilities in the rural areas is 110 which is about 95 percent of the total number of villages. The number of people served by clean and safe water facilities is 183,527 which is 56 percent of the total rural population.

The district has 2 Hospitals, 4 Rural Health Centres, Dispensaries and 43 MCH Clinics. According to URT (1997), the district had 159 Primary Schools with enrolment of 56,593

pupils. The district has 3 secondary schools with no vocational training centres. The situation with respect to the effectiveness of the extensions services is the same as what has been reported for the previous or earlier reported districts. Major constraints affecting the extension services in the district include lack of transport facilities and lack of funds for both extension work and operations.

3.2.4 Sengerema District

Sengerema District is bordered by Geita District in the South and South West, Mwanza and Misungwi Districts in the East, and by Ukerewe District in the North East. The district occupies a total area of 8,817 sq km, out of this area 3,335 sq km is dry land and 5,482 s km is covered with water. The district has 5 Divisions, 25 Wards and 124 Villages.

3.2.4.1. Landscape Characteristics

The district is characterised by gently undulating plains with occasional rocky hills/ridges surrounded by pediments leading down to depressions (mbugas). Such landscape is typical for the Sukumaland catena (Meertens et.al., 1995)

3.2.4.2. Land Use/Cover Types

Sengerema District still has remnants of natural vegetation cover as compared to other districts of Mwanza Region. This is mainly because the vegetation has been protected as forest reserves.

3.2.4.3. Rainfall Erosivity

The district has a fairly reliable rainfall spread into two rainy seasons in a year. Sengerema district receives between 800 and 1,000 mm of rain per year with a mean annual rainfall of 900 mm. Kahunda and Buchosa Divisions receive the highest rainfall. The district has moderate temperatures as compared to the other districts in Mwanza Region. Rainfall erosivity ranges from 6,000 to 10,000 $J/m^2/yr$.

3.2.4.4. Soil Erodibility

The dominant soil type in Sengerema District is Ferralic Cambisols which constitutes about 70% of the total land area in the district. This soil type is rated to be highly erodible, thus contributing substantially to soil erosion potentials in the district (Figure 10).

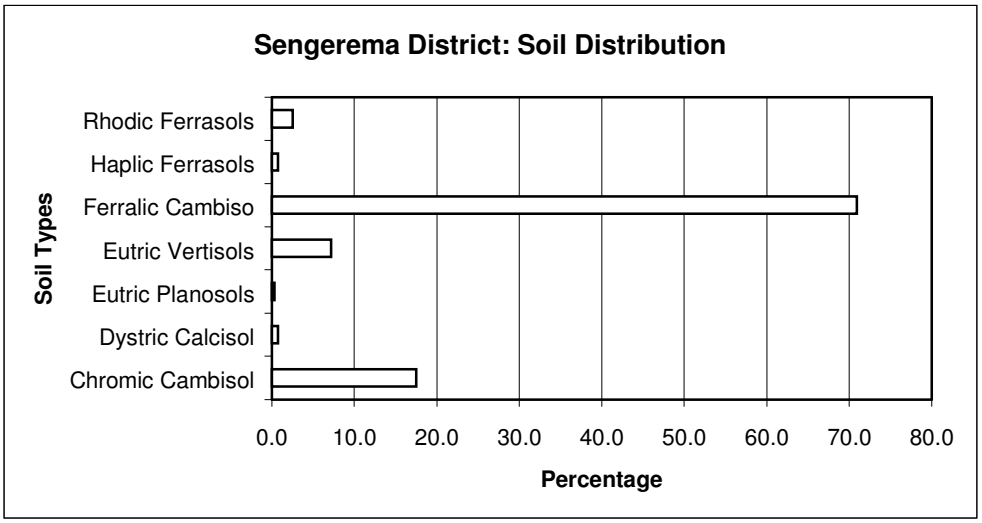

Figure 10: Soil types and their Relative Abundance in Sengerema District.

3.2.4.5. Human Population and Settlement Patterns

According to 1988 population census, Sengerema District had a population of 304,121 with a growth rate of 2.2 percent per annum. Population projection for the year 2000 was 412,907 (URT, 1997). Population density for 1995 was estimated to be 108 people per sq km. The average household size for the year 1988 was 6.5 persons. The lakeshores and areas that are suitable for crop production are densely settled. There is high population pressure in Sengerema, Kahunda and Buchosa Divisions. A significant movement of people into the district was reported, especially in Kahunda and Buchosa Divisions. Availability of fertile soils and high agricultural productivity in these divisions attract migrants from neighbouring districts, divisions, and even regions leading to land scarcity. Sengerema Division is also densely populated due to rapid urbanization in Sengerema town.

3.2.4.6. Major Economic Activities

The major economic activities in Sengerema District are agriculture, livestock keeping and fishing. The main food crops grown include maize, cassava, paddy and bananas. The cash crops are cotton, bananas and horticultural crops. Crop production is rather low due to poor or unsustainable agricultural practices. Sengerema has 155,000 hectares of arable land and 133,800 hectares of grazing area. Livestock keeping is mainly concentrated in Nyanchenche, Sengerema, Katunguru, Buchosa and Kahunda Divisions, where large livestock herds are found. According to the 1984 livestock census, the district had 119,369 cattle, 58,326 goats, 7,135 sheep and 11 donkeys. Fishing is done along the lakeshore. A large proportion of the fish catch is sold to the fish processing factories located in Mwanza and Musoma. Some of the fish are processed by sun-drying or smoking.

3.2.4.7. Socio-Economic Infrastructures/Services

The total length of the road network in is 1,024 kilometres, with 78 kilometre of trunk roads, 286 kilometres of regional roads, 428 kilometres of district roads, and 232 kilometres of feeder roads. Some roads are of gravel surface or earth surface.

About 42 percent of the urban population (16,675 people) and 34 percent of the rural population (122,949 people) are served with clean and safe water. The number of villages in rural areas provided with clean and safe water is 96 which is 77% of the total villages in the district. Areas provided with adequate water supplies attract migrants resulting into increased human and livestock population pressures and increased risks for soil erosion.

Sengerema District has one Hospital, 6 Rural Health Centres, 43 Dispensaries, and 38 MCH Clinics. Provision of adequate health facilities tend to attract migrants from neighbouring areas. According to the URT (1997), the district had 147 Primary Schools with enrolment of 51,456 pupils. The district had 4 Secondary Schools and one Vocational Training Centre.

The major constraints affecting most extension services include lack of transport to enable extension workers and technical staff to reach their clients, and limited or lack of funds for both extension services and operation.

3.2.5. Ukerewe District

The district has a total area of 6400 sq.km out of which 640sq.km is land and 5,760 sq.km is water. Administratively, the district is divided into four divisions namely Mumbuga, Mumulambo, Ilangala and Ukara.. It has 24 wards, 74 villages and 518 hamlets. There are about 27 islands in the district, the main ones being Ukerewe (490 sq.km), Ukara (80 sq.km), Irugwa (13sq.km), Bwiro (10 sq.km) and Kamasi (less than 5 sq.km). Out of the 27 islands, only 7 islands are permanently inhabited. These include Ukerewe, Ukara, Irugwa, Bwiro, Kweru, Sizu and Kamasi. The remaining 20 islands are temporarily inhabited by fishermen. In the north and east, Ukerewe District is bordered by Musoma and Bunda Districts of Mara Region, while Magu and Mwanza Districts lie in the south, and Sengerema District lies on the west.

3.2.5.1. Rainfall Erosivity

The climate of Ukerewe is humid and experiences few periods of extreme temperatures. The district has a moderate warm climate with temperatures ranging between 21°C and 27°C. The district experiences bi-modal type of rainfall. The first rains occur between September and December, and the second rains occur between March and May with rainfall ranging from 900 mm to 1,800 mm, and mean annual rainfall of 1,200 mm. In the western side, the rainfall reaches as much as 1,800 mm per annum. The humidity in the district is between 35% and 60%. Rainfall erosivity ranges from 10,000 to 14,000 J/m^2/yr.

3.2.5.2. Land Use/Cover Types

Intensively cultivated crops dominate the vegetation of Ukerewe District. As a result of the high population density mentioned above, most of the land in the district is under cultivation except where it is protected as forest reserve.

3.2.5.3. Soil Erodibility

The dominant soil in Ukerewe District is Farralic Cambisols (Figure 11) which by their nature, are highly erodible.

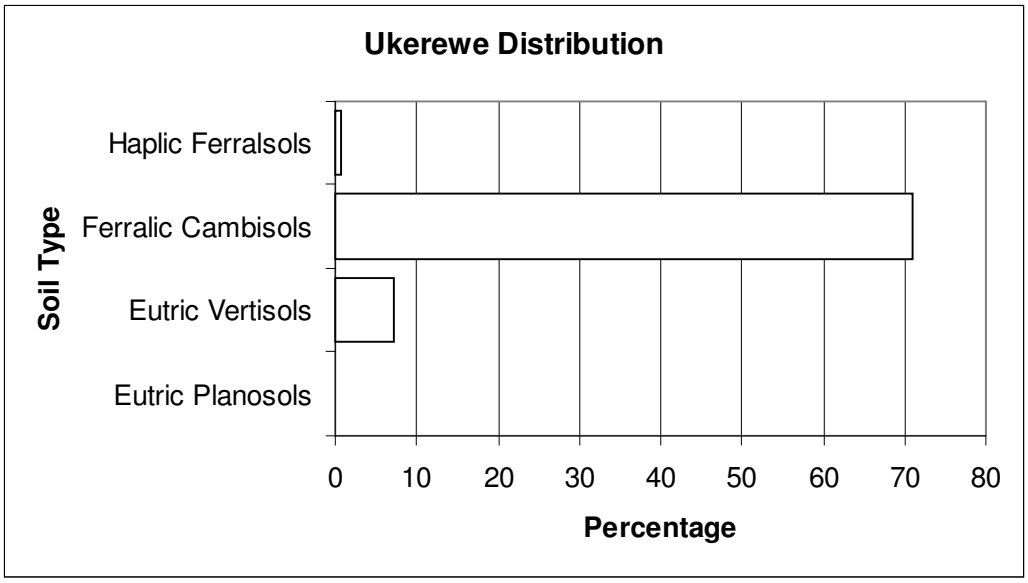

Figure 11: *Soil types and their Relative Abundance in Ukerewe District*

3.2.5.5. Human Population and Settlement Patterns

Ukerewe District had a population of 172,981 people in 1988 with an annual growth rate of about 2.2 percent per annum (URT, 1992). The population projection for 1995 was 204,179 people and that of the year 2000 was 225,127 people. The average household size is 6.8 persons. Ukerewe District has the highest population density among the rural districts of Mwanza Region. In 1988, the district had a population density ranging between 250 and 330 persons per sq. km (URT, 1992). Table 6 below shows the population distribution by wards.

Table 6. Population Distribution in Ukerewe District by Wards.

Division	Wards	Population		
		Males	Females	Total
Mumbuga	Bukongo	1,301	1,469	2,770
	Nkilizya	1,018	1,313	2,331
	Kakerege	753	860	1,613
	Mtoni	2,204	2,145	4,349
	Nansio	2,377	2,911	5,288

	Kagera	1,875	2,250	4,125
	Ngoma	2,883	9,924	12,807
	Bukanda	4,875	5,122	9,997
	Namagondo	3,925	4,013	7,938
	Mkituntu	6,802	6,876	13,678
	Total Division	**28,013**	**36,883**	**64,896**
Mumlambo	Murutunguru	6,740	7,626	14,366
	Kagunguli	9,120	8,877	17,997
	Bukindo	6,097	6,049	12,146
	Irugwa	2,358	2,548	4,906
	Total Division	**24,315**	**25,100**	**49,415**
Ilangala	Nduruma	6,133	6,701	12,834
	Bwiro	4,952	6,060	11,012
	Igalla	5,723	6,287	12,010
	Muriti	6,839	6,382	13,221
	Namilembe	5,067	5,268	10,335
	Ilangalla	10,395	11,701	22,096
	Bukungu	1,892	1,756	3,648
	Bwisya	3,812	3,874	7,686
	Total Division	44,813	48,029	**92,842**
Ukara	Nyamanga	1,765	1,888	3,653
	Bukiko	2,028	2,354	4,382
	Total Division	**3,793**	4,242	**8,035**
DISTRICT TOTAL		**100,934**	**114,254**	**215,188**

Source: Ukerewe District Council (1999)

3.2.5.6. Major Economic Activities

Agriculture and fishing are the most important economic activity in Ukerewe District. The main food crops grown are cassava, sweet potatoes, maize, paddy, sorghum, bulrush millet, legumes and a variety of fruits. The main cash crops are coffee and cotton. Crop yields are rather low due to poor agricultural practices e.g. non-utilization of fertilizers, insecticides, pesticides, improved seed varieties, poor crop husbandry.

Livestock keeping is also practiced in Ukerewe District. Livestock keeping is limited to semi-zero grazing due to shortage of pasture or grazing areas. The various types of livestock kept include cattle, goats, sheep, pigs and chickens. Concerted efforts are being made to introduce exotic breeds of cattle and goats mainly for milk production. Up to 1997 there were 495 dairy cattle in the district owned by 213 farmers. Major problems facing livestock keepers are shortage of pasture, livestock diseases such as East Coast Fever (ECF), Anaplasmosis, Pneumonia and Intestinal Worms. Inadequate veterinary services/infrastructures is another problem.

Fishing is another important economic activity in the district. The estimated fish catch between 1993 and 1997 is indicated in Figure 12. The lake fishery is negatively affected by the use of illegal fishing gears like beach seine nets, mosquito nets, dagaa nets below 10 mm, diving, weirs, katuli etc. In general illegal fishing practices have contributed to the decline or disappearance of some indigenous fish species like Haplochromine,

Protopterus, Schilbe, Alestes, Barbus, and Bargus species (Fisheries Division, 2000). Inefficient fish preservation methods are used. Similarly, many fishermen and processors are losing a substantial amount of money and food every year because of post harvest losses.

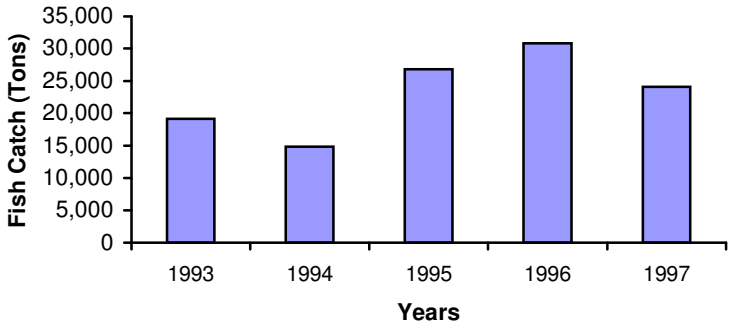

Figure 12: Estimated Fish Catch in Metric Tons (1993-1997)

Source: District Natural Resources Office, Nansio.

Fishing communities in the district have very low income from fishing activities. Fish prices are low and are controlled by fish traders and fish processing industries in Mwanza and Musoma. These factors contribute to increased poverty levels among the fishermen. There are also several environmental problems associated with fishing in Ukerewe District. These include encroachment into the identified fish breeding areas, use of unauthorized fishnets, etc. All these problems eventually lead to loss of income to the artisanal fishermen. The fishing potentials in the district are not fully exploited due to poor fishing gears and storage facilities used. Methods used in fish processing include smoking, salting, and sun drying. Generally, the fishing industry in Ukerewe District is constrained by inadequate capital of fishermen, low and unstable fish prices, poor fishing technology, poor security of fishing gears due to theft, illegal fishing and poor fish preservation method.

In addition to major economic activities carried out in the district, residents are also involved in several other income generating undertakings like petty trade, sales of forest products, carpentry works, and local beer brewing. Petty trading involves buying and selling of a wide variety of commodities. Sales of forest products include charcoal, firewood, and building materials like poles, ropes and thatch. Carpentry Work involves furniture making which are sold locally, and local beer brewing involves making local beer by using maize, cassava, finger millet and sorghum and then sold locally.

3.2.5.7. Socio-Economic Infrastructures/Services

The district has a road network of 365 kms, out of which 110 kms is regional roads, and 255 kms is district roads. With regards to water supply, only 42 villages are served with clean and safe water. The population served with clean and safe water in the urban area is

about 8,883. Ukerewe District has one Hospital, 3 Rural Health Centres, 30 Dispensaries and 28 MCH Centres. There are 81 Primary Schools in the District with a total enrolment of 37,012 pupils. The district has 3 Secondary Schools, one Teachers' College, and one Vocational Training Centre. The district has 24 Cooperative Societies which include Agricultural Marketing, Saving and Credit, Consumer, Building, Industry and Fishing Cooperatives Societies. Problems affecting extension services in Ukerewe District are the same as those already reported under other districts of Mwanza Region.

3.2.6. Misungwi Districts

Misungwi District borders Mwanza and Magu Districts in the north , Sengerema and Geita Districts in the west, Kwimba District in the east and south east, and Shinyanga Region in the south.

3.2.5.2. Land Use/Cover Types

The large proportion of the land has been put under cultivation and grazing. Paddy cultivation is predominant on depressions and pediments. Natural vegetation is confined on the rocky hills. As a result, the district experiences land degradation problems similar to those described for Kwimba District.

3.2.5.3. Rainfall Erosivity

Misungwi receives between 800 and 1000 mm of rainfall per annum. The rainfall pattern is similar to that of Kwimba District. Rainfall erosivity ranges between 6,000 and 10,000 $J/m^2/yr$.

3.2.4.4. Soil Erodibility

Dominant soil types in Misungwi District are similar to those described under Kwimba District. Proportions of extents for each soil type are included in the account for the soils Kwimba District.

3.2.5.5. Human Population and Settlement Patterns

According to the 1988 Population Census, Misungwi District was still part of Kwimba District which had a total population of 428,135 people. The population growth rate was 2.7 percent and the average household size 6.7 persons per household. Population projections for Misungwi District in 1995 was 237,297 people and the population density for the same year was estimated to be 122 persons per sq.km. Population projection for the year 2000 was 236,983 people. Like in Kwimba District, settlements have been established in areas of good agricultural potentials. Rapid expansion of urban settlements like Misungwi, Mabuki and Hungumalwa has been observed. Misungwi is the district capital and Mabuki is a settlement which attracts migrants for mining purposes. Out-migration to other districts and regions takes palce in the district. The main reasons for out-migration includes seasrch for new or productive agricultural land, and search for pasture or grazing areas. However, some cases of in-migration are reported especially in areas like Mabuki where diamond mining activities are going on.

Major Economic Activities

The main economic activities in Misungwi District are farming and livestock keeping. Some mining activities and trading are also done though at a limited extent. Food crops grown in the district include maize, paddy, sorghum, bulrush millet and cassava. Cotton and chickpeas are the main cash crops although the importance of cotton has been diminishing over time due to low price and poor marketing systems.

The 1988 Livestock Census indicates that Kwimba Districts (in which Misungwi District was a part) had 506,874 cattle, 166,445 goats, 120,589 sheep, and 4,416 donkeys. The type of cattle kept in the district is predominantly shorthorn Tanzania Zebu. There is an increase of land use conflicts especially between cultivation and livestock grazing due to population expansion in the traditional grazing areas.

Socio-Economic Infrastructures/Services

Kwimba District has 1346 kms of road network, out of which 113 kms are trunk roads, 361 kms regional roads, 364 kms district roads, and 508 kms feeder roads. With regards to the road surface, 373 kms of the roads are gravel and 973 kilometers are of earth surface. Few kilometers of the trunk roads mac on the Mwanza-Shinyanga road are tar. The proportion coverage for the provision of clean and safe water is about 57 percent of the total population. The number of villages served with clean and safe water is 43 which is about 55 percent of the total number of villages in the district. In the rural areas, about 45 percent of the population is served with clean and safe water. The district has 1 Hospitals, 3 Rural Health Centres, 31 Dispensaries, and 35 MCH Clinics. For the number of primary and secondary schools and Vocational Training Centres, see Kwimba District. Misungwi District has a total of 49 cooperative societies, which include Agricultural Marketing, Saving and Credit, Industrial, Building, Fishing, Mining and Transport cooperatives. Extension services in the district are carried out under the same problems and difficult conditions as those already discussed or reported for the other districts. Major constraints affecting the extension services in the district include lack of transport facilities and lack of funds for both extension work and operations.

3.3 Mara Region

3.3.1 Tarime District

Tarime District is located in the eastern part of Lake Victoria in Mara Region. It borders Kenya in the north, Kagera Region waters in the west, and Musoma and Serengeti Districts in the south. It has a total area of 11,137 sq.kms of which 3,885 sq.kms is dry land and 7,252 sq.kms is water. The district is administratively divided into 8 divisions, namely Inchange, Igwe, Ichungu, Inano, Girango, Nyancha, Luo-Imbo, and Suba. By 1995, the district had 40 wards and 155 villages.

3.3.1.1. Landscape Characteristics

The district is categorized into three zones, namely; the lakeshore, the midlands, and the highlands. Whereas the lakeshore zone ranges between 1,100 and 1,200 meters above seas level, the midland zone lies between 1,300 and 1,500 meters, and the highlands are

situated at an altitude of 1,500 to 1,800 meters above sea level. The midland zone is a transition area between the lakeshore and the Tarime highlands.

3.3.1.2. Land Use/Cover Types

While cultivation is predominant on the shoreline and highland zones, midland zone is characterised by grassland with patches of cultivation. Midland zone is mainly used for livestock grazing. Highland zone is cultivated with coffee and banana, thus becoming good soil protective cover from water erosion.

3.3.1.3. Rainfall Erosivity

Climate of the lakeshore zone is characterised by warm temperatures and annual rainfall of less than 900 mm falling from Mid-September to early December and from March to June. Duration of rainny seasons is highly variable. The rainfall in the midlands is highly variable and increases with increasing altitude, ranging from less than 900 mm per year near the lake shore zone to over 1,250 mm in the areas bordering Serengeti National Park.The highlands have cool temperature and receive rainfall exceeding 1,500 mm per year distributed in two rainny seasons, one from mid-February to June and the other from mid-September to the beginning of January. Rainfall erosivity in the coastal and midland zones ranges from 6,000 to 10,000 $J/m^2/yr$. However, on the highlands the rainfall erosivity ranges from 10,000 to 14,000 $J/m^2/yr$.

3.3.1.4. Soil Erodibility

While the midland and highland zones are characterised by heavy soils and deep red sandy loam soils, the lakeshore zone is characterized by poor sandy soils. The dominant soil type in the district is Gelic Phaenozems which is ranked to be very highly erodible (Figure 13).

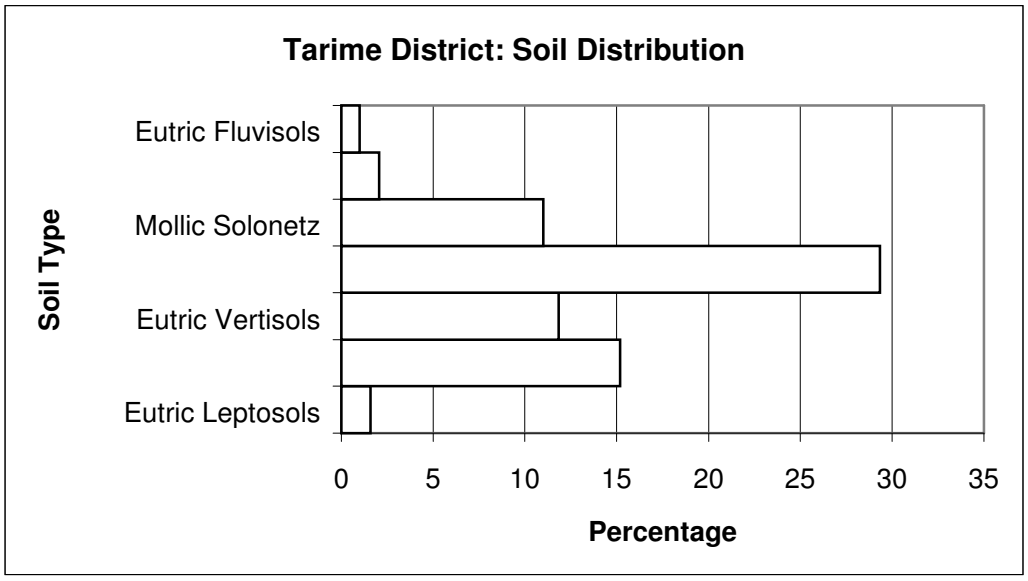

Figure 13: Soil types and their Relative Abundance in Tarime District.

3.3.1.5. Human Population and Settlement Patterns

During the 1988 Population Census, the district had 333,888 people with an average household size of 6.5 persons. The annual growth rate was 2.7 percent for the 1978/88 intercensual period. District population projections for 1995 and 2000 were 402,616 and 459,984 respectively. Large numbers of people have moved from Trime District to Musoma and Serengeti Districts in search of pasture for the livestock and arable land. With regards to settlement patterns, all rural communities are settled in villages. Areas that have good agricultural potentials and these that have good pastures and adequate water are densily populated.

3.3.1.6. Major Economic Activities

Major economic activities in the district include farming, livestock keeping, fishing and artisanal mining. The main food crops grown in the district include maize, cassava, bulrush millet, sorghum, finger millet, bananas, Irish potatoes and sweet potatoes. The district grows coffee and cotton as cash crops. Yields of crops are low especially in the Lake and Midland Zones mainly due to poor agricultural practices. According to the 1984 Livestock Census, the district had 307,694 cattle, 150,300 goats, and 69,265 sheep. Fishing activities are conducted along the lakeshore with the total area of 7,252 sq.kms particularly in Shirati and Kinesi Divisions. Mining of gold is done by artisanal miners in Nyamongo area.

3.3.1.7. Socio-Economic Infrastructures/Services

The district has a total length of road network of 1,476 kms, of which 81 kms is tarmac, 595 kms is gravel, and 800 kms is of earth surface. In 1994, the number of people served with clean and safe water in the district was 157,220, which is about 40 percent of the total population. The number of villages with clean and safe water supplies is 61 out of 155 villages with a population of 140,410 people In 1996 the district had 3 Hospitals, 5 Health Centres, 47 Dispensaries and 42 MCH Clinics. In 1995 the district had 12 Pre-schools with an enrolment of 886 pupils, 198 Primary schools with enrolment of 76.414 pupils and 8 Secondary schools. In 1995, Mara Region had 157 cooperative societies. Out of these, 153 were involved in Agricultural Marketing, 3 are Saving and Credit societies, and one is a Dairy Cattle Cooperative Society. Extension Services (Agriculture, Forestry, Fisheries, etc.). Major constraints of the extension services in the district include lack of transport facilities and lack of funds for both extension work and operations.

3.3.2 Musoma District

Musoma District borders Bunda District in the south, Serengeti District in the east and Tarime District in the north. The district occupies a total area of 4309 sq.kms. Out of this total area, 4009 sq.kms is dry land and 300 sq.kms is water. Musoma District has 4 Divisions, 39 wards and 103 villages.

3.3.2.3. Landscape Characteristics

The district is divisible into two ecological zones; the Lakeshore zone (1,100 – 1,200 m.a.s.l.) and the Midland Zone (1,300 – 1,500 m.a.s.l).

3.3.2.3. Rainfall Erosivity

The district has a tropical type of climate which is rather dry. It receives an annual mean rainfall of 700-900 mm. The eastern part of the district experiences two rainny seasons per year and this situation makes that part of the district suitable for coffee production. The temperatures are 12.9^{o}C between June and October and 34.7^{o}C between January and March. Rainfall erosivity in the coastal and midland zones ranges from 6,000 to 10,000 J/m^{2}/yr.

3.3.2.4. Soil Erodibility

The dominant soil types are Eutric Planosols and Mollic Solonetz, which are ranking as highly and very highly erodible, respectively (Figure 14).

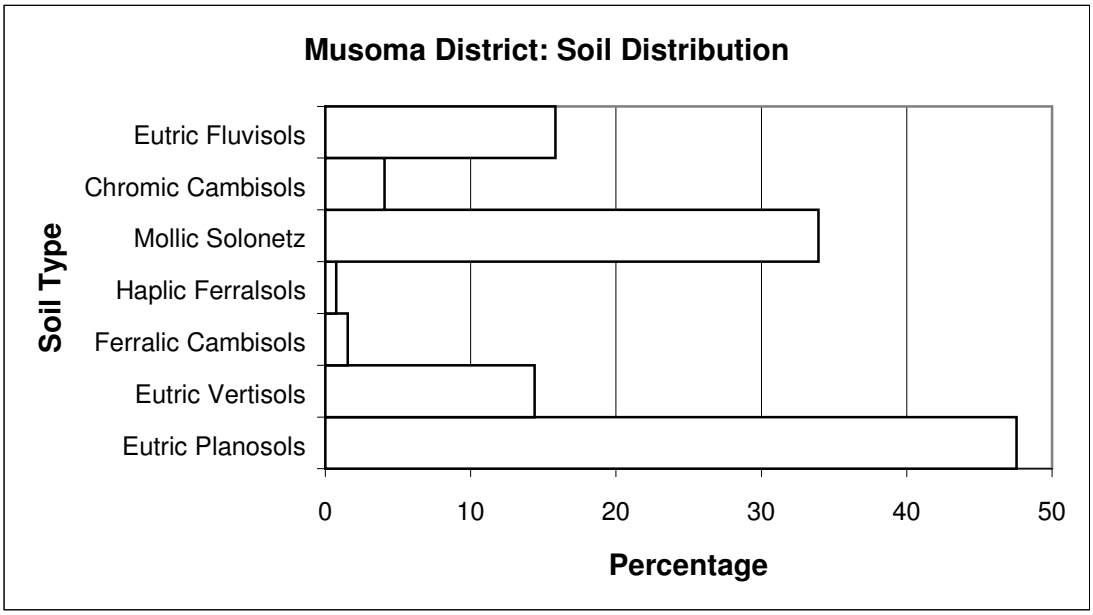

Figure 14: Soil types and their Relative Abundance in Musoma District.

3.3.2.5. Human Population and Settlement Patterns

According to 1988 population census the district had 359,978 people with the population growth rate of 2.5 percent per year. The average household size was 7.7 persons for Musoma Rural and 5.1 persons for Musoma Urban. The year 2000 population projection was 333,894 people for Musoma Rural and 115,936 persons for Musoma Urban. The mid land zone has the highest human population. The most highly populated areas are Makongoro and Nyanja Divisions as well as Buhemba and Rusori areas. Sukumas migrate to Musoma Rural District in search of arable land grazing areas thus increasing the problem of population pressure in the areas. Tarime livestock keepers also have migrated to Musoma Rural District.

Settlements have been established in areas where major economic activities are taking place e.g. along the lakeshores where fishing is done and in the eastern part of the district which receives adequate amount of rainfall and characterised by good soils where crop production and livestock keeping are practiced.

3.3.2.6. Major Economic Activities

The main economic activities in the district include farming, livestock keeping, fishing, artisanal mining, and petty trading. The major food crops grown are maize, cassava, bulrush millet, sorghum, finger millet, paddy and vegetables. The district grows cotton, coffee and sunflower as cash crops. According to 1984 livestock census, livestock population was as follows: - 272,635 cattle, 90606 goats and 40,257 sheep, and 1698 donkeys. Livestock keeping is concentrated in Ngurimi and Isenye Divisions which are located in the midlands. Artisanal mining is done in Majimoto, Kemambo, Naigoti and Rwamchanga areas.

3.3.2.7. Socio-Economic Infrastructures/Services

The district has a total length of the road network of 839 kilometres of which 59 kms is tarmac, 170 kms is gravel and 610 kms is made of earth roads. According to 1995 report, the district had 10 pumped water supplies, one dam and 99 water wells. The number of people served with clean and safe water in 1993 was 138,960 which is 48 percent of the total population. About 54 villages out 91 village had clean and safe water which is 59 percent of all villages in the district. In 1996 the district had 2 Hospital, 3 Health centres, 64 Dispensaries and 53 MCH clinics. The district has 12 Secondary schools of which 4 are government schools and 8 are private secondary schools. There were 154 primary schools and total enrolment of 68,327 pupils. Extension Services (Agriculture, Forestry, Fisheries, etc.). Major constraints of the extension services in the district include lack of transport facilities and lack of funds for both extension work and operations.

3.3.3 Serengeti District

Serengeti District is bordered by Musoma and Bunda Districts in the west, Magu and Meatu Districts in the south-west, Tarime District in the north, Ngorongoro District in the east, and Mwanza and Shinyanga Districts in the south. The District occupies a total area of 10,942 sq.km. About two thirds of the district land area is protected. The district is divided into four divisions namely Rogoro, Ngoreme, Ikorongo and Grumeti; and it has 18 wards and 74 villages.

3.3.3.1 Landscape characteristics

Serengeti District falls within the Midland ecological zone of the Mara Region. The altitude is between 1,300 and 1,500 metres above sea level. The district is dominated by plains with sparsely distributed hills.

3.3.3.2. Rainfall Erosivity

Serengeti District receives annual rainfall ranging from 800 and 1000 mm per annum. Rainfall erosivity in the district ranges from 6,000 to 10,000 J/m^2/yr.

3.3.3.3 Soil Erodibility

The dominant soil type in Serengeti District is Eutric Planosols which are ranked as highly erodible (Figure 15).

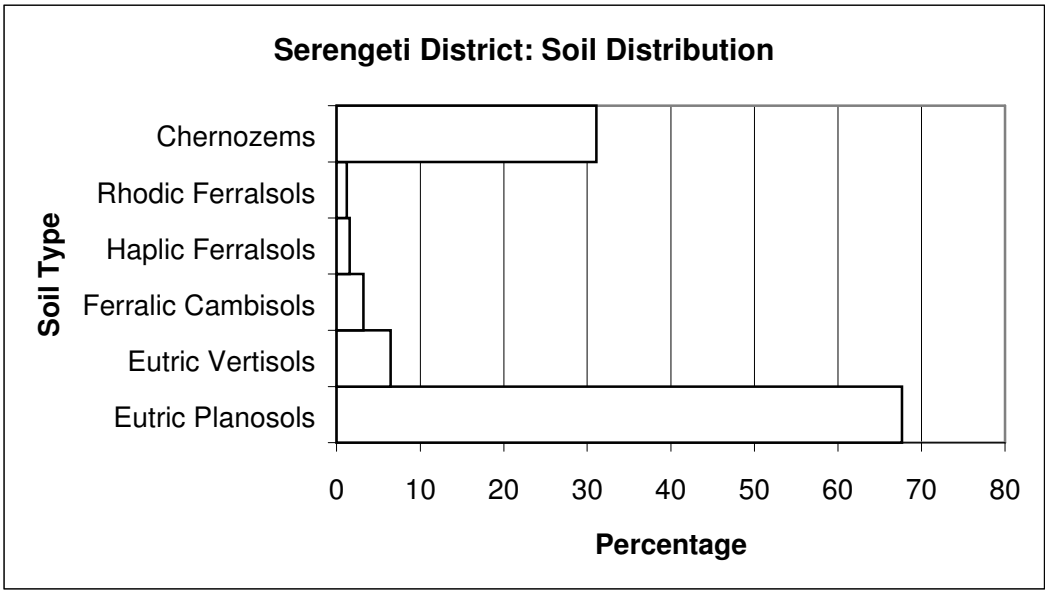

Figure 15: Soil types and their Relative Abundance in Serengeti District.

3.3.3.5 Human Population Characteristics

According to the 1978 and 1988 censuses, Serengeti District had a population of 113,283 and 129,945 people, respectively. The district growth rate during the 1978/88 intercensal period was 2.8 percent per annum. The district population was estimated to be 139,835 in 1998 (Serengeti District Council, 1999). The distribution of the population by wards is shown in Table 7.

Table 7: Distribution of District Population by Division and Wards

Division	*Wards*	*Population*		*Total*
		Males	*Females*	
Rogoro	*Mugumu*	*4,680*	*5,277*	*9,957*
	Machochwe	*4,411*	*4,971*	*9,382*
	Kisangura	*6,235*	*7,032*	*13,267*
	Rung'abure	*6,558*	*7,393*	*13,951*
	Kibanchabancha	*4,943*	*5,575*	*10,518*
	Ikoma	*6,456*	*7,279*	*13,735*
	Natta	*4,977*	*5,615*	*10,592*
	Isenye	*3,037*	*3,425*	*6,462*
	Rigicha	*2,788*	*3,142*	*5,930*
Total Division		*44,085*	*49,709*	*93,794*
Ngoreme	*Ring'wani*	*3,336*	*3,764*	*7,100*

	Nyambureti	*6,721*	*7,573*	*14,294*
	Kenyamonta	*3,672*	*4,140*	*7,812*
	Busawe	*4,787*	*5,395*	*10,182*
	Kisaka	*3,126*	*3,527*	*6,653*
Total Division		*21,642*	*24,399*	*46,041*
Total District		***65,727***	***74,108***	***139,835***

Source: SDC, 1999: 5-8).

3.3.3.6. Major Economic Activities

About 75 percent of the total population in Serengeti District is engaged in subsistence agriculture. Food crops grown include maize, sorghum, bulrush millet, cassava, finger millet, beans, paddy, sweet potatoes, simsim and groundnuts. The main cash crop grown is cotton. Coffee is being experimented in the high altitude areas and sisal has just been introduced. The district produces excess maize but there is no reliable market. Declining crop production is due to poor agricultural practices.

Livestock keeping is another important economic activity in the district. In many parts of the district wealth is based on the number of livestock owned. Serengeti District keeps about 21 percent of all livestock in the region. According to the 1995 estimates, the district had 199,533 cattle, 307, 694 goats, 150,300 sheep and 432 donkeys (URT, 1998). About 105 improved cattle were reported in 1995 (URT, 1998), but this number may have increased due to the establishment of the Serengeti Farmers Association (SEFA) in 1995 which promotes diary cattle. Overstocking is already a serious problem and likely to be even more serious with the improvement of veterinary services and the ongoing influx of livestock from the neighbouring countries.

3.3.3.7. Socio-Economic Infrastructures/Services

Serengeti District road network has a total length of 453 kilometres consisting of 127 kilometres of gravel and 326 kilometres of earth surface roads. The district has 79 kilometres of trunk roads, 121 kilometres of regional roads, 136 kilometres of district roads and 117 kilometres of feeder roads. The proportion of rural population served with clean and safe water in the district is 45 percent (about 54,178 people). About 21 villages are served with clean and safe water, which is about 35 percent of all villages. The number of people served with clean water in urban areas is 118,480, which is about 66 percent of the urban population. In 1994 Serengeti District had 1 Hospital, 2 Health Centres, 28 Dispensaries and 21 MCH Clinics. In 1995, the district had 3 Pre-schools with enrolment of 109 pupils, 79 Primary schools with enrolment of 22,783 pupils, 5 Secondary schools and one Vocational Training Centre. The entire Mara Region has 157 cooperative societies. Out of these, 153 are involved in agricultural marketing, 3 Serving and Credit Societies, and one Dairy Cattle Cooperative Society. Extension Services (Agriculture, Forestry, Fisheries, etc.). Major constraints of the extension services in the district include lack of transport facilities and lack of funds for both extension work and operations.

3.3.4 Bunda District

The district is bordered by Musoma District in the north, Magu District in the south and Serengeti District in the east. It occupies a total area of 3,088 sq.km, out of which 2,888 sq.km is land and 200 sq.km is water. Bunda has a total of 2,408 sq.km of which 480sq.km fall under the Serengeti National Park and hills. The district is administratively divided into three divisions (Serengeti, Nansimo and Kemkombyo), 20 wards, and 91 registered villages with 32,436 households.

3.3.4.1. Landscape Characteristics

The district is divisible into two homogeneous ecological zones: the Lakeshore zone (1,100 – 1,200 m.a.s.l.) and the Midland zone (1,300 – 1,500 m.a.s.l).

3.3.4.2. Land Cover/Use

Scattered cultivated crops dominate the vegetation of Bunda District. Other forms of vegetation include grasslands, woodlands, bushlands and swamp vegetation. There is a high risk of soil erosion in the cultivation and grazing areas where soil and water conservation measures are not practiced.

3.3.4.3. Rainfall Erosivity

Climate of the lakeshore zone is characterised by warm temperatures and annual rainfall of less than 900 mm falling from Mid-September to early December and from March to June. Duration of rainy seasons is highly variable.

The midland zone is a transition area between the lakeshore and the highlands. Rainfall is highly variable and increases with increasing altitude, ranging from less than 900 mm per year near the lakeshore zone to over 1,250 mm in the areas bordering Serengeti National Park. The temperature ranges from 13°C between June and October, to around 35°C between January and March. Rainfall erosivity in the coastal and midland zones ranges from 6,000 to 10,000 J/m^2/yr. However, on the highlands the rainfall erosivity ranges from 10,000 to 14,000 J/m^2/yr (Moore, 1979).

3.3.4.4. Soil Erodibility

The dominant soil types in Bunda District are Eutric Vertisols and Eutric Planosols which are ranked as very highly erodible (Figure 16).

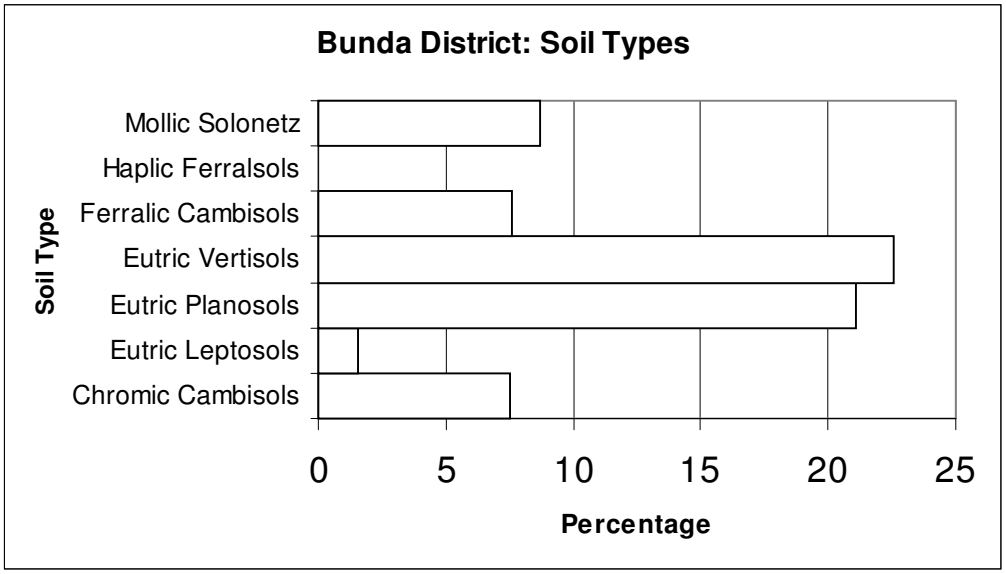

Figure 16: Soil types and their Relative Abundance in Bunda District.

3.3.4.5. Human Population and Settlement Patterns

According to the 1988 census, Bunda District had a population of 200,870 people with an annual growth rate of about 2.9 percent and an average household size of 6.8. The population projection for 1995 was 205,370 and that of the year 2000 was 283,074. The population density is estimated to be 404 persons per square kilometer. Like in other districts in the basin, settlements have been established in areas suitable for farming and livestock keeping. Lrge number of livestock keepers migrate from Sukumaland into Bunda District in search of pasture for their livestock and arable land.

3.3.4.6. Major Economic Activities

About 75 percent of the total population are engaged in subsistence agriculture. Food crops grown in the district include cassava, maize, sorghum, bulrush, millet, finger millet, paddy, sweet potatoes and groundnuts. The main cash crop grown is cotton. Coffee is being experimented in the high altitude areas. Declining crop production is due to poor agricultural practices, unreliable rainfall, pests and diseases, removal of subsidy on inputs leading to high costs of inputs, and inadequate supply of inputs. Table 8 shows declining crop production for the years 1997/98 and 1998/99 seasons

Table 8: Crop Production for 1997/98 and 1998/99

Crop	Production in Ton	
	1997/98	1998/99
Cassava	42,948.0	44,246.0
Sorghum	40,058.0	4,936.0
Paddy	44,725.0	4,854.0
Beans	4,044.0	2,484.0
Finger millet	744.0	976.0
Cotton	9,834.5	2,972.0
TOTAL	53,095.5	24,879.0

Source: District Report – Bunda (1999)

Livestock keeping is the second major economic activity in the district. According to the 1998 livestock census, Bunda District had 240,000 cattle, 70,500 goats, 43,800 sheep and 45,000 donkeys. There were also about 97 improved cattle mostly kept in Bunda Town with an average milk production of 8 litres per day per cow. The average cattle ownership per household was 6.3. Livestock stocking rate is 405 animals per sq.km.

There are a number of problems associated with livestock production. With improved livestock facilities, the livestock population is likely to increase and this will lead to environmental degradation.

Fishing is another important economic activity in the district. However, the fishing potentials in the district are not fully exploited. None of the existing programmes/projects in the district addresses the fishing sector. According to the district report (1998) on fishing, there are about 3,500 fishermen operating along Lake Victoria Shore of Bunda District. Table 9 shows fish-catch in the district between 1996 and 1998

Table 9: Fish Catch in Bunda District, 1996-1998

Year	No. of Catch (Tons)	Price per Ton (Tshs).	Total (Tshs).
2,496	200,000	499,200,000	199,200,000
3,120	200,000	1,560,000,000	4,560,000
2,808	600,000	1,684,800,000	4,684,800

Source: DNRO – Bunda 1999

Other activities include Petty Trading, Sales of Forest Products, and Local beer brewing. The items traded under Petty Trading include a wide variety of foodstuffs, small manufactured goods e.g. clothes, farm implements, etc. Forest products harvested include charcoal, firewood, thatch, building poles etc.

3.3.4.7. Socio-Economic Infrastructures/Services

Bunda District has a road network length of 605 kilometres of which 39 kilometres is tarmac, 160 kilometres is gravel, and 406 kilometres is earth surface. The proportion of population served with clean and safe water in the district is 59 percent (about 117,360 people). The district has 2 Hospitals, 2 Health Centres, 28 Dispensaries and 29 MCH Clinics. There are about 110 Primary schools with enrolment of 40,870 pupils, and 4 Pre-schools with enrolment of 8,635 pupils. Extension Services (Agriculture, Forestry, Fisheries, etc.). Major constraints of the extension services in the district include lack of transport facilities and lack of funds for both extension work and operations.

4.0. Soil Erosion Hazards

Findings from this study indicate that the influence of soil degradation factors to the actual or potential degradation varies from place to place. Thus, there are areas where degree of slope is the major factor while in other areas soil physical characteristics was seen to be the major factor. Such variations necessitate varying amelioration strategies and approaches in studying or accessing soil erosion hazards.

4.1. Causes of Erosion

Passive soil erosion factors are mentioned in Section 3. These factors constitute inherent features of the natural environment, which if disturbed give rise to accelerated soil erosion. Evidence from field observation shows signs of erosion even on the gently sloping areas and those with minimum human interference. This means that there is need to establish soil properties that lead to high erodibility. Some soils are severely eroded through rill and gully erosion and that highly eroded catchments contribute more sediment into the lake. The magnitude of contribution of each sub-catchment is yet to be established. The other factors are related to human activities which when superimposed on the passive factors lead to accelerated soil erosion. It was noted during this fieldwork that environmental degradation in the basin is mainly associated with human activities such as agriculture, livestock keeping, mining, influx of refugees and fishing activities. It was clear, for example, that population density is associated with expanded human activities like extensive cultivation and deforestation. Similarly, livestock keeping is one of the major factors contributing to soil degradation in the basin. Likewise, mining has recently emerged as a major economic undertaking that seems to have negative environmental impacts. Fishing has also an impact on the environment especially in areas where fish preservation is done by smoking. This process leads to deforestation of natural vegetation.

4.1.1. Demographic Characteristics

The linkage between demographic and the environment change is reflected in many ways, including rises in demand for food, water, fuel wood and arable land. Regions within the Lake Victoria regions are among the most populous regions in Tanzania. For example, Mwanza, Shinyanga, and Kagera Regions were ranked first, second and sixth, respectively, in terms of population size during the 1988 Population Census. In most cases high population growth is associated with depletion of natural resources if no serious conservation measures are instituted. This necessitated investigation of issues related to population dynamics, migration patterns, population density, growth rates, and the spatial distribution. Efforts to find out ways of harmonizing population pressure with the delicate environment of the lake basin and alternative strategies for utilizing existing resources under conditions of population pressure are suggested in this report.

4.1.1.1. Settlement Patterns

The impacts of demographic and urbanization trends and the expansion of agricultural activities on the Lake Victoria ecosystem (i.e. natural resource base, vegetation cover and

other socio-economic aspects) are important aspects in understanding of the linkages between settlement patterns and natural resource utilization. This understanding necessitated a deliberate investigation of the spatial distribution of settlements in relation to natural resources availability and accessibility to those resources. Such investigations enable the establishment of linkages between population dynamics and land degradation in general and soil erosion and deforestation in particular. Rapid expansion and establishment of human settlements involves clearing of vegetation cover for various purposes such as for settlement/residence, provision of building materials, cultivation, fuel wood and brick burning.

The impact of such activities on the vegetation cover reflects the settlement patterns in the basin. Both the location of communities and the spatial distribution of settlements/villages in relation to natural resources and their impacts on these resources have been observed and mapped. In most cases high population concentration was associated in a certain form with land degradation in general and erosion hazards in particular.

4.1.1.2. Migration

Population migration often has profound effects on the environment and available natural resource base. Both temporal and permanent movement of people from one location to another is largely determined by specific pull and push factors from the areas of origin and destination. In most cases, however, migrations are instigated by economic factors such as search for agricultural land, pasture or water for livestock, mining opportunities and availability of good climatic conditions for crop production. Current migration streams in the basin are mostly stimulated by rapid development in the fishing and mining industries. Due to increased rate of migration which is stimulated by the presence of new economic opportunities like mining and fish industries, the likelihood of infection rates of STIs and STDs including HIV/AIDS has increased.

4.1.1.3 Refugees Influx

An added factor observed in the basin is the existence of political turmoil in the neighboring countries. In recent years there has been an influx of refugees from Rwanda, Burundi and the Democratic Republic of Congo who were put in camps. Most of these refugees camps are located in what used to be natural environment (outside communities/villages). Evidence of the environmental degradation features around the camps demonstrates that the impact of refugees on the environment has been enormous. The presence of refugees has had serious impacts on the environment like extensive tree felling for building materials and fuelwood. Evidence of total deforestation was observed in areas surrounding former refugee camps of Benaco and Kyabalisa in Ngara and Karagwe Districts, respectively. In those areas there is completely no woody vegetation despite the fact that there were efforts in rehabilitating such sites immediately after the repatriation of the refugees and demolishing of the camps. It is interesting to note that most of these areas have now been opened up for crop cultivation conducted by the local communities as well as the refugees from the nearby Lukole A and Lukole B camps.

This situation gives an indication that more land has been opened up from woody vegetation to bare land or grassland as a result of refugee influx. Environmental implications of this ecological change is the exposure of soil to water and wind erosion as it was noted to be the case in some areas (see Photo 1).

Photo 1: *Deforestation associated with refugee influx*

4.1.1.4 Rapid Urbanization

Rapid urbanisation and unplanned settlement patterns especially in regional headquarters is a big environmental hazard as it has contributed to the clearance of natural vegetation cover and acceleration of environmental degradation processes on the surrounding hillslopes. Similarly, rapid urbanization in smaller towns like Kahama, Geita, Magu, Misungwi and Bunda has been observed to cause great harm to the environment, resulting into soil erosion. Likewise, trends have been noted in small settlements like Bulyankuru and Buselesele in Geita District, Maganzo in Shinyanga District, Chato in Biharamulo District and Mabuki in Misungwi District where vegetation cover has been cleared for various reasons e.g. settlement, mining, fuelwood, furniture, building materials, etc.

4.1.1.5 Energy Supply

Almost every household in the basin is dependent on fuel wood as a source of energy for domestic purposes, as a result the impact of energy demand on forest resources is immense. This situation is aggravated by rapidly increasing population due to natural population growth and the influx of refugees from neighbouring countries posing the leading environmental threats in the area. Even in protected areas such as forest and game reserves there is ample evidence of illegal harvesting of forest products and encroachment for agricultural expansion and grazing purposes. Clearly there is an urgent need to reduce the pressure exerted on the natural vegetation. Undertaking of massive afforestation measures and finding of appropriate alternative energy sources appear necessary. Less human-impacted vegetation cover in the area is found in localities that are remote and are of difficult access particularly those areas which are also infested with tsetse flies and thus not suitable for human habitation.

4.1.2. Farming Systems and Agricultural Practices

Farming systems refers to a wide range of farming activities and practices, technologies applied, interactions in the systems, etc, involves both crops and livestock. They may have either negative or positive impacts on land use/cover depending on their types. The negative impacts refers to environmental degradation such as deforestation, desertification, soil erosion, pollution, salination, etc.

4.1.2.1. Types of Farming Systems

During the reconnaissance trip, several farming systems were observed, and these were influenced or determined by agro-ecological zones. The differences in farming systems were a result of variations in climate (rainfall, temperature, etc.), altitude, edaphic factors, human settlements and population density, geology and landscape (terrain). The western and eastern parts of the basin portrayed marked difference in environmental potential.

It was noted that Kagera Region has some cool agricultural environments with long growing periods. Its economic development task differs slightly from that of other regions in the basin. Farming Systems in Bukoba District is based mainly on banana and coffee including maize, beans and other legumes, sweet potatoes, cassava, yams and bulrush millet as food crops. The lake shore zone covering Bugabo and Kyamtwara Divisions is densely populated, characterised by extremely fragmented holdings. The northern part of this area has poor soils. The central part which covers Katerero and Kiziba Divisions is characterized by less rainfall but soil fertility levels are high enough to allow high crop production. The southern/western zone which includes Rubale and Misenye Divisions receives low rainfall and soil fertility is high and suitable for the production of both perennial and annual crops. Mulching in banana and coffee fields is applied to reduce evapotranspiration and also to increase soil nutrients and resistance to water run off.

Biharamulo District is comprised of four agro-ecological zones. The farming systems are based on cotton, cassava, sweet potatoes, maize and bulrush millet. The main constraints in this zone are low crop productivity resulting from low soil fertility, poor soil management practices and serious competition between livestock and crops on available land. The area is vulnerable to soil erosion and already there are clear signs that soil erosion is taking place. There is potential danger of environmental degradation due to overstocking and clearing of vegetation for agricultural purposes. Most of the river water sources have their catchments cleared of vegetation for crop production and livestock grazing.

Ngara District is divided into three agro-ecological zones. The farming systems in this district are based on banana, maize, beans and other legumes. Farmers in the district practice shifting cultivation which leads to clearing of vegetation. Abandoned plots of annual crop were observed along the road from Bukoba to Ngara. Shifting cultivation coupled with annual forest fires poses great threat to the environment.

Environmental issues are being tackled by the Kagera Agricultural and Environmental Management Project (KAEMP). This project carries out afforestation programs and encourages communities to establish tree nurseries from which seedlings are obtained for starting community woodlots. It promotes organic farming by encouraging farmers to use farm yard manure instead of inorganic fertilizers.

Farming systems in these regions are based on cotton, maize, rice, sorghum and cassava, with livestock playing and important role especially for draught power. In these regions several agro-ecological zones were observed depending on the variations in climate and soils. Each of these ecological zones is associated with the particular farming system. The general problems or constraints identified in these regions are: unreliable rainfall in most districts, decrease in cotton production, poor agricultural practices, low productivity in the livestock sector and environmental degradation due to overstocking and clearing of vegetation for various purposes. In most districts extensive type of farming which involves shifting cultivation is practised. The climate of the highlands of Tarime District resembles that of Bukoba District and allows production of similar crops.

4.1.2.2 Agricultural Practices

Agricultural and livestock infrastructures/services have direct or indirect impact on the environment. Infrastructures/services do influence population dynamics and activities that may or may not be environmentally friendly. This applies mostly to agricultural, forestry and fisheries sectors. Traditional farming systems involving unsustainable agricultural practices e.g. shifting cultivation and cultivation along the slope are among the major causes of environmental degradation. It was observed that farming systems have either positive or negative impacts on the environment depending on their types. The negative impacts refer to environmental degradation such as deforestation, desertification, soil erosion, pollution, salination, tc.

Agro-pastoralism is normally practiced on pediment slopes, footslopes, and on the seasonally inundated drainage depressions. Thus, except in reserved areas (including those under "Ngitiri") where encroachment has not been severe, the natural vegetation of such locations has largely been replaced by cultivated crops or derived bush. The expansion of agriculture in areas that were traditionally used for grazing purposes has enhanced serious land use conflicts especially between agriculturalists and livestock keepers. The consequence of such conflicts is overgrazing in the reduced grazing areas leading to sheet and gully erosion. This situation is clearly evident in the eastern parts of Biharamulo District, Magu, Kwimba, Misungwi, Geita, Sengerema, Bunda and Tarime Districts (see Photo 2).

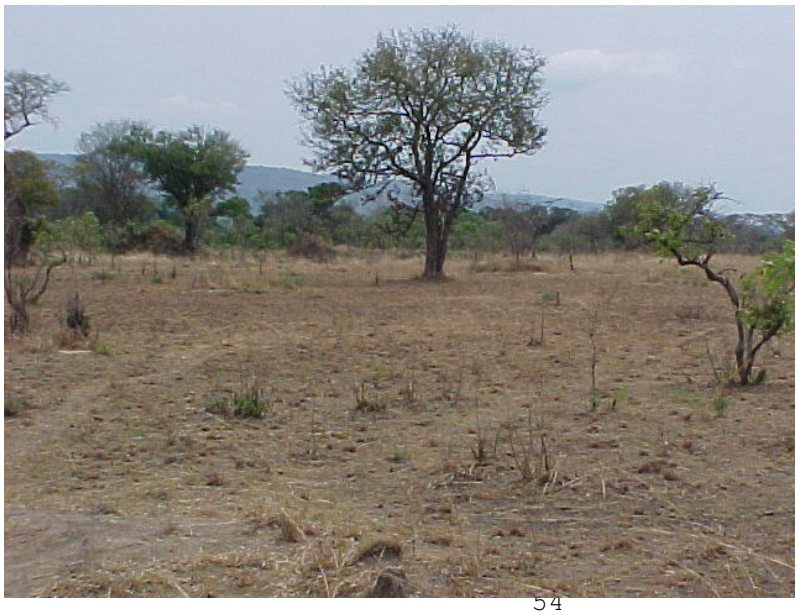

Photo 2: Overgrazing in part of Lake Victoria Basin

It has been observed that large areas of the basin have lost their natural vegetation cover through impact of human activities, such as practice of extensive agro-pastoralism, over-exploitation of forest resources, and mining. Naturally, deforestation involves removal of the land surface's protective cover, rendering it vulnerable to erosion. All the cultivated areas in the basin are therefore subject to different levels of erosion risks unless proper land management is practised.

In Kagera Region, for example, the widely used practice of heavy mulching on the cultivated slopes appear to be very effective in controlling soil erosion caused by rain-drop impact and surface wash (see Photo 3).

Photo 3: *Mulching as an effective soil and water conservation measure*

4.1.2.3 Land Tenure Issues

Land tenure influences the choice of type of land management practices to be used. Insecure land ownership may lead to the consideration of short-term gains in the land management practice. For example, shifting cultivation could be favoured leading to exhaustion of catchment forests and natural soil fertility without efforts for soil fertility restoration. The process could lead to land degradation, hence accelerating poverty.

4.1.2.4 Livestock Keeping

Traditional livestock keeping systems whereby quantity and not quality is emphasized, are among the main causes of environmental degradation in the basin. This is characterized by overstocking in many areas leading to overgrazing or removal of vegetation cover, soil erosion and water losses. Overgrazing is very common in most areas in the lake basin. This aspect is particularly conspicuous in parts of Mara, Mwanza and Shinyanga Regions where large herds of cattle are kept. High concentrations of livestock were noted in Karagwe, Tarime, Bunda, Serengeti, Magu and Kwimba Districts. In many cases these concentrations were associated with degraded rangelands and gully

formation along cattle routes. Moreover, free range grazing is the main grazing practice in almost all districts. It was, however, noted that the existing management practises play an important role in enhancing environmental degradation processes.

4.1.6 Natural Resources Exploitation

Lake Victoria Basin is endowed with large and wide varieties of natural resources which, if not protected or sustainably used could be destroyed leading to serious environmental consequences. These natural resources include forests, wildlife, land, wetlands, minerals, fish, etc.

4.1.6.1 Wetlands

Wetlands have both ecological and hydrological functions. However, such wetlands are intensively cultivated and overgrazed in regions like Shinyanga, Mwanza, and Mara Regions. The field observations indicate that such wetlands have been degraded and thus can no longer perform their ecological and hydrological functions such as trapping of sediments and biodiversity conservation. Instead, these wetlands are now contributing to sediment load into the lake.

4.1.6.2 Forests

Natural vegetation cover is rapidly being degraded from the "*cultivation steppe*" of Mwanza and Shinyanga Regions westwards threatening protected areas in districts like Geita, Kahama, Biharamulo, Ngara, and Karagwe. As a result, human induced vegetation types appear to dominate in these areas. In the eastern parts of the basin there is evidence of ongoing deforestation in Bunda, Serengeti, and Tarime Districts. In the highly deforested districts like Kwimba, Magu, Misungwi, Musoma Rural and part of Sengerema Districts land lacks vegetation cover which protects it from water and wind erosion. One of the main causes of deforestation is petty trading which involves activities such as charcoal making and firewood collection as energy sources for sale, brick and pot making, local brewing consume a lot of wood. Carpentry work and other furniture making activities use tremendous amount of wood as well.

4.1.6.3 Minerals

Lake Victoria Basin is well endowed with rich mineral deposits. Both large and small-scale mining activities are carried out. Mining is more profound in Geita, Kahama, Biharamulo, Karagwe, Musoma, Tarime, Bunda, and Misungwi Districts. In the mining areas deforestation is rampant. Small-scale mining of gold requires the use of huge amount of logs that are used to strengthen the ditches to avoid collapsing. Some of the ditches are as deep as 50 meters or more. In addition to the logs, the concentration of large population in the mining sites increases the demand for wood for domestic use. Fuel wood collection and charcoal making are supplementary activities that are conducted in the mining areas in districts like Geita, Kahama, Tarime, and Biharamulo. Charcoal making and tree felling for building purposes are very evident along the major routes linking to mining sites and major towns around mining centers.

Mining activities are not only associated with deforestation, but also with destruction of the soil surface by leaving open pits in the ground and covering the topsoil with gravel

and sub-soils. In some areas the land is abandoned after the mining activities without any rehabilitation of the land by filling in the pits. Mining is also associated with population changes due to influx of migrants as miners from various parts of the country, and health hazards especially in the mining camps.

4.1.6.4. Fish

Lake Victoria Basin is well endowed with fish resources, hence, both large and small-scale fishing is one of the major economic activities along the lakeshores. One of the ways of preserving/processing fish is by smoking. This process requires a lot of wood. The implication of this high wood demand for fish preservation/processing is deforestation along the lakeshores and beyond.

4.2. Erosion Hazard Intensity in Selected Districts

4.2.1 Bukoba District

Information from key informants in Bukoba District indicates that areas that are potential for erosion hazards include the steep escarpments immediate after the lake. Specifically, Kiziba, Bugabo, Kyamtwara, Misenyi, Rubare, and parts of Katerero Divisions are potential hazard areas. These areas have high population densities and there are many human activities going on. Given the fact that the escarpment adjacent to the lake is rocky and has poor and shallow soils, attention needs to be directed towards areas that have steep slopes. Most of the other escarpments in the district are located in protected areas like Burigi and Minziro Forest Reserves; hence, there is limited human interference on the natural ecosystem in those areas. However, there is ample evidence of encroachment by farmers and charcoal makers into these Forest Reserves.

Causes of soil erosion vary from one location to another. For example, Kiziba Division is highly populated and has poor and easily erodible soils. Moreover, the cultivation of Bambara nuts is done on ridges that are cultivated along the slopes. This practice is supported by local beliefs that if the ridges are cultivated across the slope, the husbands of those who do so may die. The persistence of such beliefs justifies the need for investment in extension services and awareness creation on sound agricultural practices to the local communities. In Bugabo and Kyamtwara Divisions, high rainfall and cultivation along the steep slopes are the major factors leading to erosion. There is also some deforestation along the lake due to fish drying/smoking activities. In Misenyi Division, overstocking, overgrazing, and uncontrolled grazing and movements of livestock are the main issues of concern. In Bugabo Division, high population pressure has made the situation worse because there are no areas for expansion and the soils are of low quality. Finally, a combination of high rainfall and unsustainable agricultural practices are responsible for land degradation in parts of Katerero and Rubare Divisions.

4.2.2 Biharamulo District

The most affected parts in Biharamulo District include the Lake Zone area which covers Nyamilembe, Buzirayombo and Bwanga Divisions. However, Bwanga Division is less affected by soil erosion because it borders forest reserves but still it is a potential hazard area. These division has high population pressure which influences deforestation and opening up of new farms even in marginal areas. Histocal tales indicate that people

migrated to these areas in the early 1960s and cleared the forest to open up new farms. With time, more and more people migrated in, population density increased, and land resources became limited. Currently, there are reports of people out-migrating from the eastern parts of the district to open farms and establish settlements in the western parts which are still covered by forests. Moreover, there is a high concentration of livestock especially in Nyamilembe and Buzirayombo Divisions. Gullies are found in most of the cattle routes due to cattle trampling. Other practices that accelerate erosion include charcoal making, bush fires, and lumbering.

4.2.3 Ngara District

The influence of refugees on the land use/cover and erosion hazards is still very eminent in Ngara District. The negative impacts of the refugee influx include massive deforestation in areas surrounding the closed and existing camps extending several kilometers from the campsites, vandalism of social service facilities, increased food insecurity and commodity prices, social insecurity, spread of HIV/AIDS, and the over-stretching of existing social service facilities. The observed rapid deforestation in the district is to a large extent a function of refugee influx.

4.2.4 Karagwe District

Information gathered from the district indicates that there are no serious cases of soil erosion in the district at the moment. Most farmers who cultivate on the hill slopes use mulching as a strategy to protect the soils especially in the Kibanja plots. However, few areas were identified to have potentials for soil erosion. These areas include Kaundwe Village in Kituntu Ward where overgrazing is the main issue, Nyabionza Division due to repetitive drought, and all steep slopes that are currently under cultivation. These areas are vulnerable to erosion unless deliberate land conservation measures are put in place. Land fallowing is practiced only by households that have large land areas. Land shortages are reported in wards like Bugene, Ihembe and Ndama due to high population pressure in those areas. Other wards that have population pressure include Kituntu and Kashanda.

There are many practices in Karagwe District that are not environmentally friendly. These include widespread bush fires, charcoal making and cultivation along the steep slopes. Fire is used in many ways. For example, farmers on the one hand, use fire to clear their farms and to burn grasses in order to keep livestock far from their farms. On the other hand, livestock keepers use bush fires as a management tool to kill ticks and to facilitate regeneration of new green grasses for the livestock (Machange, 1997). These practices increase the conflict between farmers and livestock keepers. The KAEMP[2] and KEP[3] are making efforts to increase environmental awareness among farmers and livestock keepers, especially on sustainable land use and livestock management systems. Charcoal making is another threat to the existing forest resources, especially around Kayanga town, in the Kitengule Ranch, and in other protected areas including the Burigi Forest Reserve.

[2] Kagera Environmental Management Project

[3] Kagera Environmental Project

4.2.5 Sengerema District

Almost the whole district is vulnerable to soil erosion. Specifically, Nyanchenche, Katunguru, Buchosa, Kahunda and Sengerema Divisions have clear evidence of soil erosion features. The main causes of soil erosion in this district include overcultivation, overgrazing, deforestation, and use of non-sustainable agricultural techniques. Large livestock populations are concentrated in Nyanchenche, Sengerema, Katunguru, Buchosa and Kahunda Divisions, in that order of importance. In many areas there are conflicts between livestock keepers and farmers, especially due to population pressure and expansion of agriculture into areas that were traditionally used for communal grazing. Deforestation is caused by farm expansion, fuel wood collection, charcoal making and brick burning. All these activities provide a significant threat to the existing forest resources, hence, land cover. Unsustainable farming techniques used include farming along riverbanks and lakeshore, bush clearing to establish rice farms, and use of bush fires especially in the dry season and nonuse of fertilizers to restore soil fertility.

There is high population pressure in Kahunda and Buchosa Divisions basically due to in-migration of people from other areas. The two divisions receive the highest rainfall in the district and still have fertile soils to attract new migrants. The observed migration trends have led to land scarcity in these areas. Sengerema Division also has a high population growth basically due to the influence of urban growth.

4.2.6 Geita District

The most pertinent activity in Geita District is mining which is associated with deforestation, land degradation, and water pollution. Most of the mining sites are located in areas that were previously categorized as Forest Reserves and/or farmland. The areas that have already been excavated, especially by small scale miners have been left without any form of rehabilitation. Such areas will be of no use for many years to come. Mining activities are also associated with water pollution especially when mercury is used for washing or separing gold minerals from sand, and the used water is allowed to flow back into the streams and rivers and finally into Lake Victoria.

4.2.7 Magu District

A visit was done to Kalemela Village where the LVEMP is Implementing a pilot project on working with the communities on issues related to proper management of the land. Generally, Magu District is a potential hazard area as far as land use/cover and soil erosion are concerned. The district has high human and livestock population pressure. Agricultural expansion into marginal areas and overgrazing are very evident features of the district. There is evidence of water harvesting techniques, especially in the plains where rice cultivation is done. This is a good experience which need to be encouraged. Though the land has no vegetation cover, less erosion is observed in the rice fields. Another good experience observed is the protection of the natural vegetation through community based forest management systems *(ngitiri).* This practice is a testimony that it is possible to reactivate indeginous vegetation cover in most of the Sukumaland areas.

4.2.8 Musoma District

Areas that were visited in Musoma District include Nyanja and Makongoro Divisions. Nyanja Division (Busungi and Rusori Wards) represented area that are classified as lowlands. This area is characterized by exhausted sand soils, poor vegetation cover, and high population density. There is no unused land in the Lake zone. Most of the people are involved in agriculture and fishing. The lakeshore areas which are part to Nyanja Division receive less rainfall. The combination of less rainfall and poor soils make Nyanja Division prone to food shortages. Although the lowlands are densely populated, soil erosion features are not very common. Gullies are however observed along cattle trucks. The major issues to be tackled in the zone are land degradation, especially loss of soil fertility and overgrazing. Ridge cultivation is very common and some farmers have started to practice tie ridges in their farms. Makongoro Division represents areas that are classified as Midlands. Visits were made in Butiama and Buhemba wards.

4.2.9 Bunda District

Areas visited in Bunda District include Nyamuswa (Midlands) and Kibara (Lowlands) Divisions. In Neruma Ward, livestock population, farming on steep slopes and bush fires are the main causes of soil erosion. Farming along steep slopes a major cause of erosion in Konzugu, Bunda, Sanzira, Mcharo and Iramba Wards. Soil erosion in Mugeta Ward is mainly a function of high population pressure and concentration of large herds of livestock, hence overgrazing. While Kabasa Ward is highly affected by high population pressure and soil degradation, Mihingo Ward is affected by overgrazing and deforestation. All these areas are vulnerable to soil erosion and are potential erosion hazard areas.

4.2.10 Tarime District

Tarime District covers both the Midlands and the Highlands. The soils in the highlands are of red clay type. Most of the highland areas are evergreen throughout the years and the land is almost covered by some crops all the year round. Although most areas in Tarime District have steep slopes, the farming systems practiced limit the chances of soil erosion in most farms. Cultivation is done mainly by using ox-ploughs.

4.3. Overall Observations

The case studies discussed in this section give an indication of the main features and causes of soil erosion in the basin. The most common features are population pressure, overgrazing, unsustainable agronomic practices, farm expansion through tree felling, charcoal making, mining activities, and expansion of human settlements. However, some good experiences that limit the soil erosion processes have been documented. These practices include the mulching system in Kagera Region; ridge cultivation, rain water harvesting practices, and protection of natural vegetation through ngitiri system in Mwanza Region; and the practice of tie-ridges in Mara Region. These good experiences need to be encouraged through expanded extension services to the local communities.

5. Management Practices in Different Farming Systems

It was observed during fieldwork that there are different management practices in different farming systems in the basin. The main farming systems are; banana and coffee based farming systems, and cotton and livestock farming systems as described below.

5.1 Banana and Coffee based Farming Systems

Different crops are managed differently. It was, for example, learned that banana and coffee are well managed in Kagera Region and in Tarime District (Mara Region). There are efforts to introduce coffee farming in Bunda and Serengeti Districts as well. In Kagera Region, there is an elaborate system of practising mulching in banana and coffee fields. Such a system enhances soil fertility and structure through the incorporation of organic matter into the soil. Furthermore, the system contributes to soil and water conservation. The soil is permanently covered with mulches and water infiltration is also enhanced as a result of improved soil structure. This was, however, not the case for Ngara District where people grow mainly maize, beans, bananas, and cassava on the plateau and hill slopes with limited soil and water conservation measures. There were evidence of sheet erosion in some places, particularly in cultivated fields, thus calling for introduction of soil and water conservation measures in the farm management. The area has high potential risk for soil degradation due to relief (mountainous terrain) and soil characteristics (erodible soil). It was, however, observed in some localities especially particularly in Bukoba District that some farmers make ridges along the slope on footslopes (see Photo 4).

Photo 4: Ridges along the slope direction on the footslopes

This seemed to be an environmentally unfriendly system. Explanations gathered concerning the system is that the soil is shallow and for crops to grow beds have to be raised. But also the fact that the shallow soils overly a hard pan, water infiltration is inhibited. For crops to grow, water has to be drained through furrows between the ridges.

However, to intercept the potential risk of soil erosion, the land is kept under fallow for a period of up to ten years before it is put again into cultivation. This allows the soil to restore its fertility and structural stability.

It was noted also that some wetlands are left out of human interference, thus making them function as trapping system of sediments eroded from the upland (see Photo 5). This was, however, not the case for Ngara District where valley bottoms are used for growing bananas and vegetables during the dry season, and along the lakeshores of Biharamulo, Geita, Sengerema and Bunda Districts where agricultural expansion and irrigation practices have reached the lakeshores. Such practices alter the hydrological functions of such wetlands.

Photo 5: *Non-degraded wetlands functioning as trapping system of sediments eroded from the upland*

Livestock keeping is also practised to a limited extent in the banana and coffee growing areas in Kagera region. Grazing is mainly in the plains, which are not utilised for crop growing (see Photo 6). The environmental impact of livestock grazing seems to be limited in the area because grazing land is flat to gently sloping, thus making the area less susceptible to water erosion.

Photo 6: ***Grazing in the plains with minimum impact on the environment***

Moreover, the current number of livestock is not large to the magnitude of causing overgrazing in the area. The only potential threat arises from the practise of bush fires, which seems to be common in the area. Burnt-up areas expose soil to wind and water erosion (see Photo 7). This is particularly the case for early rains before vegetation has regenerated. Burning is done as part of traditional range management practise. This practise is common all over Kagera and parts of Mara region. Another fear is the reportedly influx of cattle from the neighbouring country escaping the destocking exercise. This may ultimately lead to large numbers of livestock beyond the carrying capacity of the rangelands.

As already pointed out, refugee influx and the associated environmental problems are common in Kagera Region. It was evident that there are efforts in rehabilitation of the degraded environments, particularly in the former refugee camps. Again, vegetation regeneration of such areas requires total exclusion from human interference. But this is not the case since such areas are now used for other activities like livestock grazing and crop cultivation. There are also efforts to conserve natural environment around refugee camps. This is done through limiting refugees from cutting trees by leaving at least 40 percent of the existing trees. Refugees are encouraged to collect dead wood and plant new trees around the campsites.

However, the effectiveness of such efforts is questionable considering the large number of refugees and the associated high demand for forest products for various purposes. As a result, illegal tree cutting still prevails, particularly in areas outside the four (4) kilometres radius from the centre of the camp, which is under effective protection. Severe deforestation was noted as far as 20 kilometres from the refugee camps. Some refugees do cut trees not only for their domestic consumption but also for sale to their fellows. This business of selling wood is also undertaken by local inhabitants.

Photo 7: *Burning as a potential environmental threat*

5.2 Cotton and Livestock Based Farming Systems

This zone stretches from Biharamulo District to parts of Mara Region. This zone is characterised by low relief with inselbergs rising from extensive plains. These areas receive less rainfall as compared to the banana and coffee growing areas. Soils are sandy loamy on pediments and clay loam in the plains and valley bottoms. The Cotton Based Farming Systems zone is denuded of vegetation, except in the protected areas like Forest Reserves, Game Reserves and National parks. Vegetation disappearance in this zone is partly associated with human interference through agricultural expansion, livestock keeping, and tsetse flies eradication efforts during the colonial times. Cotton growing is of particular importance in the region. This requires extensive land at the expense of natural vegetation. Livestock keeping in this zone is traditionally an important socio-economic activity. People keep large herds of livestock which have in some areas, led to serious soil erosion through overgrazing and trampling along cattle routes and around watering points.

Few patches of intact vegetation were observed and these are traditionally managed woodlands/bushland known as ***Ngitiri*** (see Photo 8). It was learned that there are two levels of managing ***Ngitiri***, at a community and household level. ***Ngitiris*** managed by the community are larger in size, while those managed by households are smaller, and often situated close to the homestead for effective management purposes. ***Ngitiris*** have an important function in such communities where woody vegetation is a scarce resource. They are therefore not only sources of fuelwood and building poles, but also, they perform the function of providing grazing land for oxen during ploughing period.

Photo 8: Traditionally managed woodlands /bushland known as Ngitiri

In Sukumaland, contour ridging and bunding are commonly used to check erosion caused by surface wash and as water conservation measure (see Photo 9). It is however, regretting to observe that the practice of tie-ridging which had proven to be most effective in water conservation and in preventing soil erosion is presently not as widely used on account of being too laborious.

Wind erosion is widespread throughout Sukumaland because of lack of protective vegetation cover. Accelerated soil erosion is severe around watering points, which concentrate both livestock and wild animals. Commonly the surroundings of such water bodies are heavily trampled upon and the animal tracks leading into them often develop into deep gullies. It appears that in some places most of the sediments dislodged by erosion in the basin do not reach the lake. Large amounts of sediments are expected to be deposited en-route because of the low gradients characteristic of the drainage depressions emptying into the lake.

Photo 9: Contour ridging and bunding commonly used in Sukumaland

6. Conclusion and Recommendations

Conclusion

This study has provided the spatial extent and magnitude of the soil erosion in the basin and identifies priority areas for immediate interventions. Such areas are referred in this report as *hot-spot* areas. It has also examined the main factors that have contributed to the present land use practices, and the associating environmental degradation processes, and mapped erosion hazard in the basin. It has been realized that soil erosion is one of the main processes of land degradation which lead to depletion of soil nutrients in agricultural land, and degradation of wetlands through siltation and sediment deposition. The report suggests various mitigation measures that can be implemented to minimize the risks of soil erosion in the basin.

The study has confirmed that agriculture is still the backbone of the economy for the majority of the population in the basin. Despite the importance of agriculture, there has not been much technological advancement in the sector. Poor agronomic practices including extensive and shifting farming still persist and influence soil erosion processes as a result.

Among the various human activities that are practiced in the basin, extensive cultivation, mining, lumbering, charcoal making, and livestock keeping have destructive effects to land cover because of the ever increasing demand to meet the rapidly growing human population. Increased population density is often associated with expanded human activities and expanded deforestation processes. The use of traditional farming systems, for example, facilitates environmental degradation and soil erosion in particular. Similarly, the environmental implications of mining activities include large-scale deforestation and destruction of the land through digging. Further, large herds of cattle lead to overgrazing and serious land use conflicts. The expansion of agriculture in areas that were traditionally used for grazing purposes has enhanced serious land use conflicts especially between agriculturalists and livestock keepers. The consequence of such conflicts is overgrazing leading to sheet and gully erosion. These observations leads us to a conclusion that soil erosion is to a great extent a function of human activities in pursuit of their livelihood.

Findings from this study indicate that the influence of soil degradation factors to the actual or potential degradation varies from place to place. Thus, there are areas where degree of slope is the major factor while in other areas soil physical characteristics was seen to be the major factor. Such variations necessitate varying amelioration strategies and approaches in studying or accessing soil erosion hazards.

Human-induced vegetation cover is one of the remarkable feature observed in the basin. Deforestation processes have been reported since early 1860s, through expansion of the agro-pastoralism farming system, especially in Sukumaland. Such practiced were fuelled by the colonial administration through tsetse large-scale tree felling exercises. The other factor contributing to the alteration of the natural vegetation cover of the basin is uncontrolled harvesting of forest products through charcoal making, timber and large-scale fuel wood gathering for sale. The destructive nature of these activities is witnessed

along the Kahama-Ngara highway. Fishing is another important economic activity that facilitates deforestation, hence, increasing the soil erosion potentials. The use of traditional fishing gears and fish processing techniques necessitate availability of huge amount of wood, often from the natural vegetation in the basin.
Dense settlements are largely found on good agricultural land. This feature is demonstrated in Muleba, Bukoba, Biharamulo, Geita, Tarime, and Sengerema Districts where the highlands and the lakeshore are densely populated. Evidence also shows a tendency of people migrating from the eastern part of the basin towards the western part where large forest reserves and mining activities prevail. Evidence from Biharamulo District show an influx of migrants from various parts of the country and neighbouring countries searching for arable land, pasture, and other income generating opportunities like lumbering, charcoal making, hunting, and beekeeping.

Similarly, areas with mining activities also experience high population pressure. This is demonstrated by the observed rapid growth of Geita town especially after the reestablishment of gold mining activities leading to increased burden over social services and high demand for products from natural resources. Serious deforestation and land degradation were observed around mining sites. Rapid urbanisation and unplanned settlement patterns especially in regional headquarters is a big environmental hazard as it contribute to clearance of vegetation cover and accelerate environmental degradation processes.

Karagwe and Ngara District experienced an influx of huge refugee populations in the 1990s. The negative impacts of the refugees include massive deforestation in areas surrounding the camps, vandalization of social service facilities, increased food insecurity, high commodity prices, social insecurity, and high risks of HIV/AIDS infections. Apart from refugees from Rwanda and Burundi, migrants from Uganda also enter the basin mostly in search of pasture. These are causing land pressure or land shortage in the basin.

Most parts of Kagera Region practice land management systems that are sustainable. The Kibanja system, for example, comprise a mixture of banana, coffee, beans, maize and many other annual and tree crops. Fallowing is often practiced in the Kikamba system where land is sometimes left fallow and used for annual crops.

There is also evidence of declining crop production in many parts of the basin. The decline in production is largely caused by the declining use of agricultural inputs due to non availability and/or high prices. The decline in use of inputs is mainly attributed to the removal of subsidies on agricultural inputs and poor performance of cooperatives in relation to marketing and supply of agricultural inputs. Farmyard manure and mulching practiced are used in areas like Bukoba, Ngara and Karagwe to replenuish the soil fertility in farms.

Passive soil erosion factors constitute inherent features of the natural environment, which if disturbed give rise to accelerated soil erosion. There is evidence of erosion even on the gently sloping areas and those with minimum human interference. Some soils are severely eroded through rill and gully erosion and that highly eroded catchments contribute more sediment into the lake.

Almost every household in the basin is dependent on fuel wood as a source of energy for domestic purposes; as a result the impact of energy demand on forest resources is immense. This situation is aggravated by rapidly increasing population due to natural population growth and the influx of refugees.

Differences in farming systems seem to be a function of variations in climate (rainfall, temperature, etc.), altitude, demographic factors, geology and landscape (terrain). In Kagera Region, for example, the widely used practice of heavy mulching on the cultivated slopes is very effective in controlling soil erosion caused by rain-drop impact and surface wash. Mulching in banana and coffee fields is applied to reduce evapo-transpiration and increase soil nutrients. The farming systems in Biharamulo District are based on cotton, cassava, sweet potatoes, maize and bulrush millet. In Ngara District the farming systems based on banana, maize, beans and other legumes and some farmers practice shifting cultivation which leads to clearing of vegetation. Farming systems in Mara, Mwanza and Shinyanga Regions are based on cotton, maize, rice, sorghum and cassava, with livestock playing and important role especially for draught power. In these regions, demographic pressures have played a role in influencing changes in the farming systems. Traditional farming systems involving unsustainable agricultural practices e.g. shifting cultivation and cultivation along the slope are among the major causes of land degradation in general and soil erosion in particular.

Recommendations:

In order to clearly understand the prevailing human activities taking place in basin, detailed and regular socio-economic surveys are required. This is important because there is need to determine the socio-economic changes that are taking place and their implications for better natural resource management in the future. Socio-economic surveys can also be used to establish the drivers of changes in land cover that trigger erosion processes. Such information is important in explaining the various behavioural aspects of the local communities and the erosion hazards in the basin.

Clearly there is an urgent need to reduce the pressure exerted on the natural vegetation through massive afforestation measures and searching for appropriate alternative energy sources.

Causes of soil erosion vary from one location to another. There is evidence that demonstrate the influence of cultural beliefs on the agricultural behaviors of the population in the basin. Similarly there are many practices that are not environmentally friendly. These include widespread bush fires, charcoal making and cultivation along the steep slopes. The persistence of such beliefs justifies the need for investment in extension services and awareness creation on sound agronomic practices to the local communities.

The areas that have already been excavated, especially by small scale miners have been left without any form of rehabilitation. Such areas will be of no use for many years to come, hence need immediate rehabilitation. Attention should be directed to strengthening community involvement and participation in any form of rehabilitation activities to ensure sustainability.

The case studies discussed in this report give an indication of the main features and causes of soil erosion in the basin. The good experiences observed to limit soil erosion

processes include the mulching system in Kagera Region; ridge cultivation, rainwater harvesting practices, and protection of natural vegetation through *ngitiri* system in Mwanza and Shinyanga Regions; and the practice of tie-ridge cultivation and ox-ploughing across the slopes in Mara Region. These experiences need to be encouraged through expanded extension services to the local communities. The ngitiri system, for example, is a testimony that it is possible to reactivate indigenous vegetation cover in most of the Sukumaland areas.

This study has been going on for over one year. A lot of information has been availed with respect to land use/cover and erosion hazard in Lake Victoria Basin. A number of conclusions and recommendations can therefore be drawn out of this study.

6.1. Conclusion

This study has demonstrated that overlay method is simple to use in the assessment of soil erosion hazard. It also gives an indication of the situation on the ground. This is a practical approach in situations where there are limited quantitative data. It, however, faces some limitations as its assessment is qualitative in nature and gives equal weight to all the variables (e.g. slope, rainfall, soil, land cover/use types). This is often not the case as in some areas one parameter may have more weight than other parameters.

An attempt made to quantitatively assess soil erosion rate in the basin using Universal Soil Loss Equation proved to yield good results. However, information generated during this study will have to be validated by estimating erosion rates at plot level in representative units of soil erosion intensities. Such quantitative datasets will help to improve the USLE Model to suit the local environment.

Soil erosion has been identified in this study as one of the main processes of land degradation in specific areas (hot-spots) of Lake Victoria Basin leading to depletion of soil nutrients on agricultural land, siltation of wetlands and sediment deposition into the lake. The consequences of this process are the declining of agricultural production and destruction of fish habitats.

It has now been confirmed that natural factors and human activities in pursuit of their livelihood are responsible for the initiation and acceleration of soil erosion and also for variations in intensity/magnitude of soil erosion hazards in different parts of the basin.

Severity/extent of soil erosion varies from one place to another depending on bio-physical factors (slope, rainfall, soil, land cover/use types) in the area and socio-economic activities (farming, mining, livestock keeping, lumbering, etc.) being undertaken.

The estimated soil erosion rate should not be considered as the amount of sediments deposited in the lake, some are re-distributed within the basin, particularly in catchments characterized by broad and swampy flood plains.

It is possible to reverse the process of soil erosion and thus minimizing the rate and extent of environmental degradation by introducing appropriate interventions.

6.2. Recommendations

- The report should be published in form of a book for distribution to interested parties, particularly those who are involved in various forms of interventions in the basin.

- Information generated during this study should be packaged, if possible be translated into Swahili for a wider leadership and disseminated to the various stakeholders in the districts with specific recommendations.

- Different information dissemination techniques could be applied such as running of workshops/seminars in each district where by specific findings and recommendations will be submitted for discussion. These should be attended by: MPs, District Executive Directors, Municipal and Town Directors, Councilors, Heads of Departments, Village Executive Officers, Representatives of NGO's, CBO's and religious organisations.

- Different stakeholders at national, regional, district, ward and village levels should be assigned specific responsibilities or roles aimed at environmental conservation or protection in general and specifically in combating erosion hazards.

- District programmes should be developed focussing on erosion control measures and catchment or group approach should be used.

- There are instances whereby two or more districts or regions geographically share the same catchment area and the associated environmental problems or erosion hazard in particular. These districts or regions should jointly form an organ that will address these issues.

- Formulation of regional database and harmonisation of methods/approaches and data sets generated on soil erosion.

- In order to monitor and clearly understand the environmental changes and the associated human activities taking place in the basin, detailed and regular bio-physical and socio-economic surveys are required. This is important because there is need to determine such environmental and socio-economic changes that are taking place and their implications for better natural resource management in the future.

- There is evidence that demonstrate the influence of cultural beliefs on the agricultural behaviors of the population in the basin. Similarly there are many practices that are not environmentally friendly. These include widespread bush fires, charcoal making and cultivation along the steep slopes. The persistence of such beliefs justifies the need strengthening extension services and awareness creation on sound agronomic practices and environmental conservation to the local communities.

- The areas that have already been excavated, especially by small scale miners have been left without any form of rehabilitation. Such areas will be of no use for many years to come, hence need immediate rehabilitation. Government should allocate part of the income generated from mining sector to rehabilitate the affected areas.

- The case studies discussed in this report give an indication of the main features and causes of soil erosion in the basin. The good experiences observed to limit soil erosion processes include the mulching system in Kagera Region; ridge cultivation, rainwater harvesting practices, and protection of natural vegetation through *ngitiri* system in Mwanza and Shinyanga Regions; and the practice of tie-ridge cultivation and ox-ploughing across the slopes in Mara Region. These experiences need to be encouraged through expanded extension services to the local communities. The ngitiri system, for example, is a testimony that it is possible to reactivate indigenous vegetation cover in most of the Sukumaland areas. In additional to the above-mentioned practices which are already in place, efforts should be made to encourage livestock keepers to reduce the number of livestock they own and improve the quality of the remaining ones.

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Appendix 1

Data dictionary – survey and mapping of land cover / use and erosion hazard potential in lake victoria basin

Data is organised in different directories as follows:

1. Basin Level

There are four sub directories at basin level as follows:

C:\MwanzaBasin\ Contours

Sub-directory containing the basin contour shape file.

File naming system:

Contour.shp is the name of the shape file.

C:\MwanzaBasin\ Landcover

Sub-directory containing the basin Land Cover / Use shape file.

File naming system:

Lclu.shp is the name of the shape file.

C:\MwanzaBasin\ FS

Sub-directory containing the basin Farming Systems shape file.

File naming system:

Fs.shp is the name of the shape file.

C:\MwanzaBasin\ Soil

Sub-directory containing the basin soil shape file.

File naming system:

Basin.shp is the name of the shape file.

2. Catchment Level

C:\MwanzaBasin\Catchments\

The Catchment sub-directory contains nine sub-directories named after each sub-catchment as follows:

C:\MwanzaBasin\Catchments\Duma
C:\MwanzaBasin\Catchments\Grumeti
C:\MwanzaBasin\Catchments\Kagera
C:\MwanzaBasin\Catchments\Mara
C:\MwanzaBasin\Catchments\Mbalageti
C:\MwanzaBasin\Catchments\Simiyu
C:\MwanzaBasin\Catchments\SmithSound
C:\MwanzaBasin\Catchments\Suguti

Under each sub-catchment's directory, there are fives shape files for the sub-catchment boundary, farming systems, soil, land cover / use and erosion hazard potential.

File naming system:

Catchment boundary: The first three letters of the catchment followed by "dist" e.g. *grudist.shp* for Grumeti sub catchment.

Farming systems: The first three letters of the catchment followed by "fs" but separated by an under score e.g. *gru_fs.shp* for Grumeti sub catchment.

Soil: The first three letters of the catchment followed by "soil" but separated by an under score e.g. *gru_soil.shp* for Grumeti sub catchment.

Land Cover / Use: The first three letters of the catchment followed by "lcu" but separated by an under score e.g. *gru_lcu.shp* for Grumeti sub catchment.

Erosion hazard potential: The first three letters of the catchment followed by "eh" but separated by an under score e.g. *gru_eh.shp* for Grumeti sub catchment.

3. District Level

C:\MwanzaBasin\Districts\

The Districts sub-directory contains twenty one sub-directories named after each district e.g. **C:\MwanzaBasin\Districts\Kwimba**

Under each district sub directory, there are nine shape files for the district boundary, farming systems, soil, land cover / use and erosion hazard potential, rivers, roads, Settlements and water bodies (lakes).

File naming system:

District boundary: The first three letters of the district followed by "dist" e.g. *kwidist.shp* for Kwimba district.

Farming systems: The first three letters of the district followed by "fs" but separated by an under score e.g. *kwi_fs.shp* for Kwimba district.

Soil: The first three letters of the district followed by "soil" but separated by an under score e.g. *kwi_soil.shp* for Kwimba district.

Land Cover / Use: The first three letters of district followed by "lcu" but separated by an under score e.g. *kwi_lcu.shp* for Kwimba district.

Erosion hazard potential: The first three letters of the district followed by "eh" but separated by an under score e.g. *kwi_eh.shp* for Kwimba district.

Rivers: The first three letters of the district followed by "rivers" e.g. *kwirivers.shp* for Kwimba district.

Roads: The first three letters of the district followed by "roads" e.g. *kwiroads.shp* for Kwimba district.

Settlements: The first three letters of the district followed by "setts" e.g. *kwisetts.shp* for Kwimba district.

Lakes: The first three letters of the district followed by "lakes" e.g. *kwilakes.shp* for Kwimba district.

4. Shape File Properties

4.1 Contours

Shape file : Contours *(contour..shp)*
Feature class: Point
Units: Metres

Attributes of important fields in Contour Shape File

Northing - X coordinate of the point

Easting - Y coordinate of the point

Alti_m - Altitude in metres

Alti_f - Altitude in feets

Summary of attributes:

	Attribute	Definition	Data Type
1	Northing	X coordinate	Number
2	Easting	Y coordinate	Number
3	Alti_m	Altitude (m)	Number
4	Alti_f	Altitude (f)	Number

Source of Data

This dataset was obtained by digitising contours on 1:250,000 base maps. The contours in arc (line) form were then converted to points using ArcView and MS Excel. It was found to be insufficient so extra point i.e. trig points were digitised from corresponding 1:50,000 base maps. The resulting shape file went through interpolation to create a GRID from which slope was derived. This was only done at basin level. The slope classes thus obtained were then combined with other parameters in a matrix to generate Erosion Hazard Potential.

4.2 Erosion Hazard Potential

Shape file : Erosion Hazard Potential e.g. *kwi_eh.shp*
Feature class: Polygon
Units: Metres

Attributes of important fields in Erosion Hazard Potential Shape Files e.g. *kwi_eh.shp*

Area - Area of each polygon (sq. m)

Sum_eh - sum of Erosion Hazard Potential for each parameter

Mean_v - Mean value of the parameters

Range - Qualitative classification of each parameters follows:

Range	Classification
1	Insignificant
2	Significant
3	Very Significant

Veg_des - Land Cover / Use description

Vegcode - Land Cover / Use code

Eh_lcu - Erosion Hazard Potential for Land Cover / Use

Main_type - Major soil type

Eh_class - Soil Erosion Hazard Potential

Gridcode - Slope category

Eh_sl - Slope Erosion Hazard Potential

Fsname - Farming system name

Eh - Erosion Hazard Potential for the Farming System

Summary of attributes:

	Attribute	Definition	Data Type
1	Area	Area of polygon	Number
2	Sum_eh	Sum of Erosion Hazard (EH) values	Number
3	Mean_v	Mean value of Erosion Hazard	Number
4	Range	Qualitative classification of EH	String
5	Veg_des	Land Cover / Use	String
6	Vegcode	Land Cover / Use code	String
7	Eh_lcu	Land Cover / Use Erosion Hazard Potential	Number
8	Major_type	Major soil type	String
9	Eh_class	Soil Erosion Hazard Potential	Number
10	Gridcode	Slope category	Number
11	Eh_sl	Slope Erosion Hazard Potential	Number
12	Fsname	Farming system	String
13	Eh	Farming system Erosion Hazard Potential	Number

Source of Data

This dataset is a combination of all the parameters used to derive Erosion Hazard Potential. The source of each parameter will be described under the corresponding shape file properties.

4.3 Farming Systems

Shape file : Farming Systems e.g. *kwi_fs.shp*
Feature class: Polygon
Units: Metres

Attributes of important fields in Farming Systems Shape Files e.g. *kwi_eh.shp*

Area - Area of each polygon (sq. m)

Perimeter - Perimeter of the polygon

Major_crop - Major crops in the Farming Systems

Fsname - The Farming System name

Soil_fert - Qualitative classification of soil fertility as follows:

S/No.	Classification
1	Low
2	Low to moderate
3	Moderate
4	Moderate to high
5	High

Eh_fs - Erosion Hazard Potential for the Farming System

Summary of attributes:

	Attribute	Definition	Data Type
1	Area	Area of polygon	Number
2	Major_crop	Major crops of the Farming System	String
3	Fsname	Farming System	String
4	Soil_fert	Farming System Erosion Hazard Potential	Number

Source of Data

This dataset was obtained from Mlingano Soil Research Centre, Ministry of Agriculture and Food Security.

4.4 Land Cover / Use

Shape file : Land Cover / Use e.g. *kwi_lcu.shp*
Feature class: Polygon
Units: Metres

Attributes of important fields in Land Cover / Use Shape Files e.g. *kwi_lcu.shp*

Area - Area of each polygon (sq. m)

Perimeter - Perimeter of the polygon

Veg_des - Land Cover / Use description

Vegcode - Land Cover / Use code

Eh_lcu - Erosion Hazard Potential for Land Cover / Use

Summary of attributes:

	Attribute	Definition	Data Type
1	Area	Area of polygon	Number
2	Perimeter	Perimeter of the polygon	Number
5	Veg_des	Land Cover / Use	String
6	Vegcode	Land Cover / Use code	String
7	Eh_lcu	Land Cover / Use Erosion Hazard Potential	Number

Source of Data

Land Cover / Use is based on visual interpretation and intensive field verification of Landsat 7 data of 1999/2000 using the following bands 4 (Red), 5 (Green) and 3 (Blue). Supplementary information was obtained from Land TM of 1994/95 and aerial photographs of different years and scale.

4.5 Soil

Shape file : Soil e.g. *kwi_soil.shp*
Feature class: Polygon
Units: Metres

Attributes of important fields in Soil Shape Files e.g. *kwi_eh.shp*

Area - Area of each polygon (sq. m)

Perimeter - Perimeter of the polygon

Soil Type - Code for soil type

Main_type - Major soil type

Eh_class - Soil Erosion Hazard Potential

Summary of attributes:

	Attribute	Definition	Data Type
1	Area	Area of polygon	Number
2	Perimeter	Polygon perimeter	Number
3	Soil_type	Soil type symbol	String
4	Main_type	Major soil type	String
5	Eh_class	Soil Erosion Hazard Potential	Number

Source of Data

This dataset was obtained from Mlingano Soil Research Centre, Ministry of Agriculture and Food Security.

4.6 Rivers

Shape file : Rivers e.g. *kwirivers.shp*
Feature class: Line (Arc)
Units: Metres

Attributes of important fields in Rivers Shape Files e.g. *kwirivers.shp*

Length - Length of a river segment

Rivname - Name of the river

Summary of attributes:

	Attribute	Definition	Data Type
1	Length	Length of a segment	Number
2	Rivname	Name of the river	String

Source of Data

This dataset was extracted from Land Cover / Use based on Landsat TM of 1994/95. Supplementary data obtained by digitising 1:250,000 base maps from Survey and Mapping and Division.

4.7 Roads

Shape file : Roads e.g. *kwiroads.shp*
Feature class: Line (Arc)
Units: Metres

Attributes of important fields in Roads Shape Files e.g. *kwiroads.shp*

Length - Length of a road segment

Roadtype - Classification of the road as follows:

S/No.	Classification
1	All Weather Road: Bound Surface
2	All Weather Road: Loose Surface
3	Dry Weather Road
4	Other tracks and Footpath

Summary of attributes:

	Attribute	Definition	Data Type

1	Length	Length of a road segment	Number
2	Roadtype	Road category (classification)	String

Source of Data

This dataset was obtained by digitising 1:250,000 base maps from Survey and Mapping and Division.

4.8 Settlements

Shape file : Settlements e.g. *kwisetts.shp*
Feature class: Point
Units: Metres

Attributes of important fields in Rivers Shape Files e.g. *kwirivers.shp*

Name - Name of the settlement

Summary of attributes:

	Attribute	Definition	Data Type
1	Name	Name of the Settlement	String

Source of Data

This dataset was ed by digitising 1:250,000 base maps from Survey and Mapping and Division.

4.9 District Boundary

Shape file : District Boundary e.g. *kwidist.shp*
Feature class: Polygon
Units: Metres

Attributes of important fields in Rivers Shape Files e.g. *kwirivers.shp*

Area - Area of the polygon

Perimeter - Perimeter of the district boundary

Summary of attributes:

	Attribute	Definition	Data Type
1	Area	Area of the polygon	Number
2	Perimeter	Perimeter of the district boundary	String

Source of Data

This dataset was extracted from Land Cover / Use data based on Landsat TM of 1994/95. Supplementary data obtained by digitising 1:50,000 base maps supplied by Surveys and Mapping and Division.

5. ArcView Project

The main ArcView Project File *(Lvempi.apr)* is in the following Directory: C:\MwanzaBasini\

There is a separate ArcView Project File for each district and each sub catchment in their respective sub directories. The name of the ArcView Project File corresponds to the name of either a district or a sub catchment e.g *kwimba.apr* or *Mbalageti.apr*

6. Legends

There is a legend file for each shape file (layer or theme). The legend files with an extension "avl" are located in the following directory: **C:\MwanzaBasin\Legends\.** The legend files are named as follows:

Fs.avl	Farming Systems legend
Fs_eh.avl	Farming Systems Erosion Hazard Potential legend
Lcu.avl	Land Cover / Use legend
Lcu_eh_avl	Land Cover / Use Erosion Hazard Potential legend
Soil.avl	Soil Types legend
Soil_eh.avl	Soil Erosion Hazard Potential legend
Roads.avl	Roads legend
Settlements.avl	Settlements legend