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LAKE VICTORIA ENVIRONMENTAL MANAGEMENT PROJECT II

TRANSBOUNDARY DIAGNOSTIC ANALYSIS (TDA) OF THE LAKE VICTORIA BASIN

FINAL REPORT

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ACRONYMS AND ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
BMU	Beach Management Unit
BOD	Biological Oxygen Demand
CAB	Regional Centre for Bioscience
CBO	Community based organizations
CDC	Centres for Disease Control
CITES	Convention on International Trade in Endangered Species
CMS	Convention on Migratory Species
COD	Chemical Oxygen Demand
CPUE	Catch Per Unit Effort
CSOs	Community Service Organizations
DFID	Department for International Development
D.Phil	Doctor of Philosophy
EAC	East African Community
ECOVIC	East African Communities Organization for the Management of Lake Victoria
EEC	European Economic Community
EIA	Environmental Impact Assessement
EIS	Enviornmental Information Systems
EQO	Environmental Quality Objectives
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
FITCA	Farming in Tsetse fly Controlled Areas
GDP	Gross Domestic Product
GEF	Global Enviornment Facility
GIS	Geographical Information Systems
GOK	Government of Kenya
HACCP	Hazard Analysis and Critical Control Points
Hg	Mercury
HIV	Human Immuno-deficiency Virus
IBA	Important Bird Areas
ICRAF	International Centre for Research on Agroforestry (World Agroforestry Centre)
IFMP	Implementation of Fisheries Management Plan for Lake Victoria
ILO	International Labour Organization
IMO	International Maritime Organization
IUCN	International Union for Conservation of Nature (The World Conservation Union)
KARI	Kenya Agricultural Research Institute
KDHS	Kenya Demographic Health Survey
KEFRI	Kenya Forestry Research Institute
KEPHIS	Kenya Plant Health Inspection Services
KIPPRA	Kenya Institute of Public Policy, Research and Analysis
KIWASCO	Kisumu Water and Supply Company
KMFRI	Kenya Marine and Fisheries Research Institute
KWS	Kenya Wildlife Service
LBDA	Lake Basin Development Authority
LVB	Lake Victoria Basin
LVBC	Lake Victoria Basin Commission
LVDP	Lake Victoria Development Program –Phase I
LVEMP	Lake Victoria Environmental Management Project
LVFO	Lake Victoria Fisheries Organization
LVFRP-I	Lake Victoria Fisheries Research Project Phase I

LVFRP-II	Lake Victoria Fisheries Research Project Phase II
M. Phil	Master of Philosophy
M.Sc	Master of Science
MoLFD	Ministry of Environment and Livestock Development
MAC	Maximum Allowable Catch
MCS	Monitoring Control and Surveillance
MDGs	Millenium Development Goals
MENR	Ministry of Environment and Natural Resources
MPPI	Major Perceived Problems and Issues
MMNR	The Masai Mara National Reserve
NACC	National Aids Control Council
NBI	Nile Basin Initiative
NEJLV	Network for Environmental Journalist of Lake Victoria
NEPAD	New Partnership for African Development
NGOs	Non-Governmental Organization
NORAD	Norwegian Agency for Development Cooperation
OSIENALA	Osiepe Nam Lolwe kod Aluorane (Friends of Lake Victoria)
PATEC	Pan African Tick and Environment Control
PDNO	Public Data Network Operators
Ph.D	Doctor of Philosophy
PIC	Prior Informed Consent
PMCT	Prevention of Mother to Child Transmission
POPs	Polychlorinated Organic Pollutants
PRA	Participatory Rural Appraisal
SAP	Structural Adjustment Programme
SAREC	Swedish Agency for Research Cooperation
SIDA	Swedish International Development Agency
SWOT	Strengths, weaknesses, opportunities and threats
TDA	Transboundary Diagnostic Analysis
THg	Total Mercury
TN	Total Nitrogen
TOR	Terms of Reference
TP	Total Phosphorous
UNCC	United Nations Convention on Climate Change
UNCED	United Nations Conference on Enviornment and Development
UNCCD	United Nations Convention to Combat Desertification
UNFCC	United Nations Framework Convention on Climate Change
USAID	United States Aid for International Development
VCT	Voluntary Counseling and Testing
VICRES	Victoria Research
WLL	Wireless Local Loop
WUCST	Western University College of Science and Technology
WWF	World Wildlife Fund

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EXECUTIVE SUMMARY

This is a report of the Transboundary Diagnostic Analysis (TDA) of the Lake Victoria basin, focusing on the Kenyan catchment. The study was commissioned by the Ministry of Environment and Natural Resources (MENR) as part of the preparation for Lake Victoria Environmental Management Project Phase II (LVEMP-II) and was implemented between October 2005 and August 2006. The objective of the study was to prepare a TDA in order to identify a Strategic Action/Investment Program (SAP) addressing key environmental issues and poverty alleviation by promoting sustainable economic growth.

Data and information for TDA were collected through; Desk review of relevant literature, analysis of empirical data and interview of key stakeholders using questionnaires and Participatory Rural Analysis (PRA) methods. The main findings were validated and new information acquired through various local and national meetings and workshops. In particular the stakeholder workshops held on 24 March 2006 in Nairobi and on 26-28 April 2006, 21-23 June 2006 and 22-23 August 2006 in Kisumu, provided key input to the process. The Global International Waters Assessment (GIWA) model was used, which consists of scaling, scoping, causal chain analysis and policy options analysis. The GIWA model enabled the identification of the major perceived problems and issues (MPPI), analyses of information generated and formulation of remedial measures.

The TDA identified the main primary productive sectors in the Lake Victoria basin as; Land, water, agriculture, livestock, fisheries, forests, wetlands, mining, energy, wildlife and tourism (cultural sites). Fisheries is among the most important resources of the lake basin, with a production value of about $88 million, export value of $60 million and contributes about 0.5% of Kenya's GDP. Lake Victoria is Kenya's dominant fish source, with three commercial fish species; Nile perch (*Lates niloticus*), Nile tilapia (*Oreochromis niloticus*) and 'dagaa' (*Rastrineobola argentea*), which constitute over 95% of total fish catch.

Agricultural production is another mainstay of the lake basin economy. The main food crops include; maize, beans, rice, cassava, sweet potato, Irish potato, sorghum, wheat, millet, banana, pineapples, groundnuts, simsim, cowpeas, green grams, soybeans, tomato and a wide variety of indigenous and exotic fruits, vegetables and other horticultural crops. The main cash crops are; Sugar cane, tea, coffee, pyrethrum, tobacco, sunflower, cotton and pyrethrum. The livestock industry is based mainly on cattle, goats, sheep, pigs and poultry. The main products are milk products (milk, ghee etc.), meat products (beef, mutton, chicken etc.), eggs, hide and skin. There are about 1.5 million cattle within the catchment and a high number of local breeds of goats and sheep within the catchment. The major livestock diseases in the basin are; Trypanosomiasis, East Coast Fever, Anaplasmosis, Babeosis, Heartwater, Newcastle disease, Foot and mouth disease, Rift Valley fever, rabies etc.

Forests contribute immensely to the basin's economy by providing wood and non-wood forest products for commercial and domestic use. The wood products support the pulp and paper industries, sawmills, the building and construction industry, charcoal and firewood production and transmission posts for telephone lines. Non-wood products and services include; woodcarving, beehives, wildlife sanctuary,

cultural and tourist sites. Forests also provide fruits and nuts, medicinal plants, wild vegetables, water and fish. The main sources of energy are wood fuel, electricity and oil. Other potential energy sources such as solar, geothermal and wind energy are not significantly developed. Wind power is used mainly to pump water in a few parts of the basin and to propel sail boats in the lake. Hot springs are present in parts of the basin, but these have not been exploited for geothermal energy. Similarly, conversion of solar power to electric energy is least exploited.

Mining takes place in isolated areas in the basin. Gold has been the main industrially mined mineral in the basin, however, deposits are exhausted. Other minerals are copper, base metals, rare earth elements, Kisii soapstone, phosphate, sulfur, Wollastonite and nephelinite, manganese, tin, kaolin, clay, flourspar, iron ore, graphite, sheltie, diatomaceous soil, and building material (limestone, granite, brick clay, sand, tuffs, murrum and material for ballast).

Tourism has much potential. Some of the important and famous gazetted National Parks, such as Masai Mara, Mt. Elgon and Ruma are within the Lake Victoria basin. The immediate Lake Victoria circuit (the so-called 'Western Tourist Circuit') is perceived to be of high tourist potential, though, still not well developed. Potentials for tourism include; the landscape, the people, sacred and cultural sites, pre-historic sites, pre-colonial fortified sites; indigenous forests, the lake, islands, and lake resources; wild game, and numerous natural features.

The TDA identified a number of transboundary major perceived problems and issues (MPPI) and analysed their impacts. The analysis involved assessment of the root causes, specific sources, locations and sectors for each MPPI. The identified MPPI were; Decline in certain endemic and commercial fish stocks, threats to biodiversity, overall declines in environmental quality (water quality, quantity and sedimentation), climatic change/ variability, degradation of catchments landscapes and damage to catchments habitats, invasive and introduced species, deteriorating infrastructure and amenities, decline in human health, conflicts in resource use and floods in parts of the lake basin.

There has been a general decline in the major commercial fish species in Lake Victoria. The main causes of fisheries decline are: Habitat degradation, lack and/or mis-management of fisheries leading to overexploitation, worsening geopolitical and economic climate causing negative impacts such as poor enforcement of, and compliance with, fishing regulations, open access policy, insufficient scientific knowledge of how fish species may adapt to changing environment, possible eutrophication effects on plankton; lack of alternative livelihoods and poverty.

There is concern over widespread loss of biodiversity in Lake Victoria (at species, genetic, and habitat levels). Most affected are fisheries, forestry and a range of wild fauna and flora. The major factors threatening decreased biodiversity of the basin are; Interference with inflowing rivers, water destruction, illegal fishing and over-fishing, water level changes, pollution, invasive and introduced species, climate change, deforestation, illegal hunting and open access policy of most natural resources.

There has been an overall decline in environmental quality. The main environmental components of concern are; air and water quality. Air pollution mainly results from

emission from factories. The main issues in relation to water quality are; Discharge of agro-chemicals into rivers and lakes, persistent organic pollutants (POPs), biological oxygen demand (BOD), high levels of faecal coliforms and disposal of domestic and industrial wastes. The main causes of water pollution are; Improper use of agro-chemicals on farms, improper runoff and drainage systems, discharge of raw and untreated sewage into rivers and lakes.

There has been climatic variability and change that has contributed to the current condition of Lake Victoria. Some of the common manifestation of climatic change in the lake basin are; temperature rise (global warming), flooding, changing rainfall pattern, severe droughts, increase in severe weather events e.g. *el nino* etc. The main causes of climate changes are; Emission of carbon dioxide and deforestation.

There has been huge degradation of catchment landscapes. The lake basin has lost a large portion of its vegetative cover and soils. This has caused damage to the catchment habitat and degradation of landscape. The immediate causes are deforestation, soils erosion, poor farming practices and overstocking livestock. Inadequate compliance with and enforcement of legal regulations, weak economic situations, absent or inadequate national and regional EIA processes, population growth and inadequate public awareness are the underlying causes. As a result of the degraded landscape there have been problems with transboundary transport infrastructure. The main means of transboundary transport are by road, water and air, however, they are inadequate and mostly dilapitated.

The Lake Victoria basin has experienced invasive and introduced faunal and floral species over the years. The most adverse invasive species in the basin are; Nile perch, water hyacinth and striga weed. The impacts of Nile perch and water hyacinth are confined to the aquatic environment, while striga has adversely affected agricultural productivity. Other invasive weeds with less devastating impacts include duck weed, *Lantana camara*, African marigold, *Solanium nigrum* and Mexican marigold.

The lake basin is prone to serious human, livestock and crop diseases and pests. The lake basin faces serious challenges in health and socio-economic development. At the Lake's shores the incidence of malaria is amongst the highest in the world, closely followed by HIV/AIDS. The major human diseases are; HIV and related illnesses (HIV/Aids, Tuberculosis, Upper respiratory infections, Meningitis, Pneumonia, Anaemia), Vector-borne diseases (Malaria, Schistosomiasis, Trypanosomiasis), Water-borne diseases (Typhoid, Cholera, Amoebiasis). The most common animal diseases within this region are Trypanosomiasis, East Coast Fever, Anaplasmosis, Babeosis, Heartwater, Newcastle disease, Foot and mouth disease, Rift Valley fever, rabies etc. The warm and humid lake basin environment also favours numerous crop diseases and pests.

There have been persistent resource use conflicts in the lake basin. In the recent past, the Lake has witnessed conflicts in resource use, including; cattle rustling, access rights, cross-border fishing, water use, wetlands degradation, forest destruction, wildlife migration and increased incidences of bush fires. There are also conflicts in opinion regarding management, conservation and use of natural resources between various groups.

Flooding is a persistent problem in the flood plains of Lake Victoria. In particular Kano Plains, Lower Nyakach and Budalangi areas are flooded annually during long rains, and even sometimes also during short rains. The major rivers flowing into Lake Victoria that are prone to cause floods are rivers Nyando, Sondu-Miriu, Yala, Nzoia and the joint Migori/Kuja. Floods cause disruption to livelihoods and cause families to incur unexpected costs, which is usually very high. It includes the costs of settlement in new areas and resettlement back in their homes after floods recede. Farming and other economic activities are also seriously disrupted when people have to move out of their farms in affected areas. Floods destroy infrastructure, social amenities and degradation of landscape through soil erosion. Flooded areas are also prone to water-borne and water-related diseases such as Malaria, Bilharzia and intestinal infections.

There are a number of emerging issues identified in this TDA. They include; Changes in the lake levels, avian flu, bio-availability of nutrients, negotiating the Nile treaty, highland malaria, eucalyptus pest (Blue Gum Chalcid), recycling of solid waste, developing alternative energy sources, value addition in the primary productive sectors, and controlling floods in the lake basin.

The TDA sets three broad Environmental Quality Objectives (EQO), namely: balanced aquatic ecosystem, stabilised high quality fresh-water supply, and sustainable land use. A number of EQO targets have been proposed in this TDA, with a target accomplishment date of 2015. They include; achievement of adequate surface water quality, restoration of natural surface water flow, achievement of sustainable fisheries development, arrestation of wetland loss, achievement of adequate freshwater quantity, achievement of adequate ground water quality and quantity, reduction of the rate of land degradation by 20%, reduction of catchments erosion rates by 25%. Also included are the activities and the specific interventions to achieve the targets. These targets are in line with the objectives of the Millenium Development Goals.

This TDA recognises the need to have a balanced aquatic system, stabilised high quality fresh-water supply and sustainable land use. For these to be achieved specific actions will have to be taken targeting the key sectors, namely; water, solid waste management, disaster preparedness, invasive species, fisheries, wetlands, biodiversity conservation, land use, energy, mining and forestry. The following actions are recommended to achieve the objectives for those sectors.

For water quality, it will be necessary to establish an environmental toxicology referral laboratory to generate information on human and environmental risk assessment studies, establish common methods for assessing water and sediment quality, including bioassays of lake biota, and fill gaps in knowledge of priority pollutants and contaminants.

To ensure adequate water quantity, it will be necessary to achieve adequate freshwater quantity, ration water use through international agreement on shared water basin, achieve adequate ground water quality and quantity, and fill gaps in knowledge, improve efficiency and availability of high-quality well water, reduce evaporative losses in drainage basin, rationalize the use of small dams and barrages for local communities and regenerate (reforest, replant) the drainage basin to increase natural evapotranspiration processes.

For water basin management, there is need to agree regionally on extraction of river/Lake water and control outflow, conduct baseline investigation to establish the minimum threshold required for ecosystem function, manage water release from hydro-electric dams in accordance with natural requirements, manage water usage for agriculture and other uses in order to maintain more natural river/lake water level and prevent detrimental impact on the ecosystem, develop regional commission with appropriate policy/legal basis to monitor regional water quantity and quality, implement regional EIA for water management projects to enhance broad stakeholder involvement in major water projects, develop regional lake basin water management plan of action and strengthen the capacity of institutions to implement regional basin water management plan of action.

For solid waste management, there is need to construct or extend sewage collection systems in all major cities in the basin and routine discharges to treatment, upgrade/renovate existing treatment plants for mechanical and biological treatment, expand solid waste (plastics) collection in all major cities and improve disposal methods so waste does not run-off or leach into waterways, develop biodegradable packaging materials, reduce impacts of industry and mining on water, develop and enforce regulations on the disposal of industries and mining effluents, strengthen the capacity of institutions to enforce mining and industry regulations and implement demonstration projects to bring best technology and practice to industrial discharges (e.g. pre-treatment, source control, process control).

To ensure disaster preparedness, there is need to put in place disaster Management measures and operationalise the toxic chemical/oil spill contingency plan prepared under LVEMP1. To achieve the objectives for invasive weeds management, there is need to halt the spread of aquatic weeds, improve knowledge of distribution of aquatic weeds using regional groups, enforce sanitary and phytosanitrary standards (SPS), develop national and regional aquatic weed management strategies /plans/frameworks combined with monitoring and GIS capacities, and establish and implement a control system for the import and export of exotic species into and from the Lake.

For the fisheries sector there is need to ensure that legislation regulating gear, quotas, size limits, seasons and allowed fishing areas are in place, strengthen enforcement of size limits, season, etc., relying on community-based fishery management activities such as the BMUs, help harmonize fishing regulations amongst lake basin countries, strengthen capacity of institutions such as Fisheries Department to enforce fisheries regulations, establish “no take zones or breeding grounds” either geographically or seasonally, establish criteria for “healthy” fisheries situation, develop site-specific management plans that promote sustainable utilization and protect nursery or reproduction areas and provide alternative technologies. Further effort should be put on enforcement of sanitary and phytosanitary measures and value-added fisheries products.

For the wetlands sector there is need to arrest wetland loss, fill gaps in knowledge of priorities in protecting wetlands**,** strengthen regional legal basis for protection of wetlands and develop management plans for selected wetland sites of global and ecological importance. To achieve the objectives for biodiversity conservation, there

is need to develop and implement regional biodiversity conservation strategies, prevent adverse human activity on sensitive areas and reduce impacts of agriculture, land grazing and hunting on loss of biodiversity. There is need to control invasive weeds.

For the energy sector, effort should be put on alternative sustainable energy sources, particularly focusing on bioenergy, geothermal, solar, wind, wave and current energy, and creation of a regional energy market. With regard to mining there is need to evaluate national legislation addressing mining and use of non-living resources, organize artisanal miners into viable production and marketing units, improve value addition of mineral resources, enhance access to credit and develop innovative monitoring and evaluation system.

For the agricultural sector there is need to develop programs to reduce impact of agriculture and animal husbandry, agree to a list of banned agrochemicals, develop a program to destroy stored banned products, develop strategies to encourage the sustainable use of organic manure fertilizer, agree on regional controls on bushfires for agriculture, pasturage, and hunting, and enforce the controls; Conduct training courses at farmer and industry level, strengthen and enforce regulations on the disposal of animal waste, develop more efficient ways to use existing land, increasing yields through better land management, crop rotation, or crop selection. Also develop basin-wide corridors for seasonal migration of livestock through adjacent countries, based on historical common use zones; Develop community-based agricultural and animal husbandry networks for transfer of technology and best practice, establish regional and national capacities to monitor, examine causes, and map (using GIS) geographic locations of agriculture and animals husbandry, including protection objectives and disseminate the results to rural inhabitants. There is also need to develop programs for improved marketing chains, improved value addition of agricultural products targeting export markets, guaranteed minimum returns and improved access to credit. Effort should also be put on enhancing capacity for irrigated agriculture (e.g. Rehabilitate irrigation schemes), diversification of enterprises and crop uses and on research and extension services.

For proper land use there is need to reduce rate of land degradation by 20% by 2015, strengthen regional legal basis for preventing land degradation, strengthen capacity of institutions to implement National Plans of Action and EIA process review, determine and satisfy training needs in region for land-based activities and sources, develop educational programs at all levels on land-based (LB) activities and sources, develop Regional/ Governmental/ Private Sector partnerships on land-based activities and sources, strengthen legal basis and institutional capacity to reduce impacts of agriculture and animal husbandry, develop programs to reduce impact of agriculture and animal husbandry, establish and maintain a network of well-managed protected area in the Lake Victoria basin and reduce land degradation due to mining, stone quarrying and brick making. While for the forest sector, there is need to reduce rate of forest destruction, reduce rate of loss of land to desertification, develop culturally-adopted improvements to land tenure system/property rights in the region, reduce catchment erosion rates and fill gaps in knowledge.

Other cross-cutting recommendations are to develop innovative monitoring and evaluation systems, develop sustainable funding mechanisms, pursue ecosystem management of Lake Victoria basin and control and manage HIV/AIDS.

This report consists of ten sections. Section 1 provides background information on Lake Victoria, focussing on the state of the environment, the political situation, socio-economic conditions, and legal/ regulatory framework, and introduces the primary sectors relevant to this TDA. Section 2 discusses the methodology used for data collection and analysis, while section 3 presents a comprehensive situational analysis of the lake basin, including; the physical and biogeochemical characteristics, environmental quality, biodiversity, the natural resource base, productive sectors, health status and socio-economic dimensions, among other key issues and sectors. Section 4 discusses the policy, legal and institutional setting, including; conventions, treaties and policies relevant to the lake basin. Section 5 presents detailed information on Transboundary major perceived problems and issues (MPPI), while section 6 discusses the process and results of stakeholder analysis. Section 7 presents some of the emerging issues in the Lake Basin and Section 8 presents the environmental quality objectives and targets. The summary and conclusion of TDA are given in section 9 and recommendations in Section 10.

This TDA is distinct as the first and most comprehensive analysis of water-related issues on the Lake Victoria basin, focusing on Kenyan catchment. It is intended that it will create a benchmark for further monitoring of the health of the basin ecosystem. This process will also strengthen other efforts within the framework of the Nile Basin Initiative and provide a basis for the formulation of recommended options for improving the environmental situation and ensuring sustainable development of the Lake Victoria basin.

SECTION 1. BACKGROUND

This section provides background information on Lake Victoria basin focussing on the state of the environment, the political situation, socio-economic conditions, and legal/ regulatory framework. Finally it introduces the primary sectors relevant to this TDA.

1.1. Introduction

Transboundary Diagnostic Analysis (TDA) is a scientific and technical assessment through which transboundary water-related environmental and economic issues and problems are identified and quantified and their causes analysed and impacts assessed. The analysis involves an identification of causes and impacts of issues at defined boundaries, including local, national, regional and global levels paying attention to the socio-economic, legal, political and institutional context within which they occur. This involves identification of the root causes, specific sources, locations and sectors.

Examples of previous TDA studies include; in Caspian Sea (2002), Benguela Current, Lake Tanganyika, West Indian Ocean (2002), Volta River basin (2002) and Gulf of Honduras (2003). Those studies helped to identify major perceived problems and issues, their root causes, impacts and identification of intervention. In Lake Victoria, there has been sectoral causal chain analysis of environmental issues (Odada *et al.* 2004), however, there has been no comprehensive TDA, hence, the need for this study.

The preparation of the current TDA for Lake Victoria basin involved the assessment of the impacts (both environmental and socio-economic) of transboundary issues, and the identification of non-environmental factors such as institutional, legal and policy issues. Within the context of the TDA, transboundary environmental issues addressed fell in the following categories.

a) National issues with transboundary causes and/or sources.
b) Transboundary issues with national causes and/or sources
c) National issues requiring a common strategy and collective action to address.
d) National issues having transboundary elements or implications (e.g. fishing practices on biodiversity/ecosystem resilience).

1.1.1. Geographic description of Lake Victoria basin

Lake Victoria, with a surface area of 68,800 km^2, is Africa's largest and the world's second largest freshwater lake. It lies at an altitude of 1135 m above sea level and touches the Equator on its northern reaches. It is relatively shallow, reaching a maximum depth of about 79m, and an average depth of about 40m. The lake is shared by three east African countries, with Tanzania having 51% (35,088 km^2), Uganda with 43% (29,584km^2) and Kenya with 6% (4,128 km^2). The Lake has a catchment area of about 194,200 km^2, shared among five states as follows; Tanzania 44% (85,448 km^2), Kenya 22% (42,724 km^2), Uganda 16% (31,072 km^2), Rwanda 11% (21,362 km^2) and Burundi 7% (13,594 km^2) (Piper *et al*. 1986).

The Lake was formed by down warping of the earth's crust and it came into existence during the last 400,000 years. According to Johnson *et al*. (2000), the lake dried up entirely about 15,000 years ago due to a climatic phase of extreme dryness. Presently, precipitation is the main source of water into Lake Victoria accounting for 3613.8 m^3/s (81.9 %) while the rest, amounting to 796.6 m^3/s (18.1 %), comes in through rivers. Evaporation at the rate of 3,330.3 m^3/s (75.9 %) accounts for the major loss of water from the lake, the rest (24.1%) being lost through River Nile outflow at rate of 1057.6 m^3/s. The flushing time (volume/average outflow) is 138 years and the residence time is 21 years.

Figure 1.1 Map of Lake Victoria, Kenya and its catchment **(From LBDA, 2004)**

Lake Victoria contains numerous islands and has a highly indented shoreline estimated to be about 3,460 km long. The Lake surrounds several groups of large islands (e.g. Sesse or Kalangala and Buvuma in Uganda; Ukerewe in Tanzania; Rusinga and Mfangano in Kenya), and many small ones. The Lake is a global centre

of aquatic biodiversity, and its catchment form a basin that is valued for its socio-economic potential in addition to its immense ecological values. The economic potential of the catchments is based on the rich agricultural soils, abundant rainfall, and significant minerals deposits, among others. The Lake is one of the unifying factors for the three Partner States in addition to having a critical importance to the region's society and economy as a source of food, potable water, transportation, agricultural water, power production and tourism. As the world's largest freshwater fishery, the benefits of Lake Victoria are global with significant local consumption and exports, in particular to the European Union, Middle East, Asia and the Far East.

The lake basin in Kenya covers 28 districts distributed in three provinces, namely; Bondo, Gucha, Homabay, Kisii Central, Kisumu, Kuria, Migori, Nyamira, Nyando, Rachuonyo, Siaya, Suba in Nyanza Province; Bomet, Buret, Kajiado, Kericho, Nandi, Trans Mara, Trans Nzoia and Uasin Gishu in Rift Valley, and; Bungoma, Busia, Butere-Mumias, Kakamega, Lugari, Mt. Elgon, Teso and Vihiga in Western Province (Fig. 1.1). Eight of these districts have their border extending into the lake itself, with Suba and Bondo the most embedded, having about 80% and 40% respectively of their territory under water.

1.1.2. Demographic factors

The lake basin has about 30 million residents, representing about one-third of the population of the riparian states. Kenya has the largest population density in the basin, hosting 38% of the population, followed by Tanzania (19%) and Uganda (15%). The rest of the population is in Rwanda (19%) and Burundi (9%) (NEJLV, 2002). The lakeshore population is rapidly expanding in line with the fast national population growth rates of the riparian countries. The Lake, the lakeshore and the lake basin are obvious engines of economic growth in countries where poverty alleviation is of high priority. The rapidly increasing population has put pressure on the basin's limited resources, resulting in competition and conflicts over access rights and threats to sustainable use of resources.

1.1.3. The Basin's economy

The main natural resources in the Lake Victoria basin are: land, water, fisheries, forests, wetlands, minerals, pastures, energy, wildlife and natural heritage. These constitute the main primary sectors on which agriculture, livestock, tourism and infrastructure are based.

1.1.3.1. Water resources

The Lake Victoria basin is endowed with the lake, dams, rivers, ponds, reservoirs. Water is the most important resource base for Lake Victoria basin whose availability and quality is probably often taken for granted by many stakeholders. The basin consists of large catchments that receive heavy rains resulting in large volumes of surface runoff flowing into the rivers. Rivers such as Sio, Nzoia, Yala, Nyando, Sondu Miriu, South Awach, North Awach and Gucha originates from the mountainous ecological zones. Groundwater is also abundantly available and is drilled to supplement areas of water deficit. The rapidly growing urban and peri-

urban centres located within the catchment of Lake Victoria basin have contributed to increased environmental degradation through uncontrolled municipal and industrial effluents from the breweries, textile dyeing, tanning, fish and agro-processing industries, which pollute the rivers and the lake (UN-HABITAT, 2005). The Lake has experienced a decline in water quality since the 1960s. For instance, phosphorus concentrations and algal biomasses have increased significantly, leading to filamentous and colonial blue-green algae dominating the algal community (Lunga'yia *et al*. 2000; Kling *et al.* 1998). The polluted state of the lake also resulted in water hyacinth invasion in the mid- to late 1990s. Water hyacinth reduced the efficiency of operation of the Owen Falls hydroelectric plant and blocked access to ports, fish landings and watering points. It interfered with fishing operations, fishing boats and gears, recreational activities and commercial transportation services for people and goods. It led also to increased water loss through excessive evapotranspiration, destruction of fishing grounds through lack of light, nutrients and oxygen and provided favorable habitat for disease vectors. By 1998 the weed occupied over 17,000 ha and nearly 90% of shoreline in Kenya (Othina *et al*. 2003; Njiru *et al.* 2002). The water quality changes favoured the success of the Nile perch and contributed to the reduction of endemic fish species. Paper and sugar industries within the catchment of Lake Victoria are a cause of concern due to their discharges to the river flowing into Lake Victoria. There has been an outcry over the discharge of chlorine and offensive sludges into rivers within the basin.

There are numerous challenges of water and sanitation in the major towns in the Lake Victoria basin. These include;

a) The water production is far below the demand production. In Kisumu City the production is 18, 500 m^3/day against a demand of 45 000 m^3/day
b) Most of the water infrastructure is old consisting of very old pumps, pipes and valves that cannot sustain the workload.
c) Only a small fraction of the population is served. For instance in Kisumu city, 40% of the estimated population is the only fraction served as at 2006.
d) Most of the informal settlements are not connected. For example in Kisumu city the informal settlements comprise 50-60 % of the population and these have no access to potable water.
e) In Kisumu city and Homabay, the conventional treatment systems have collapsed and for Kisumu city raw sewage enters the lake through Kisat and into Kisumu bay.
f) More than 50% of the consumers don't have working meters.

In Kisumu city the inauguration of the Kisumu Water and Sanitation Project (KWSSP) through funding from France is expected to improve the health and quality of life of the population in the town by improving their access to water supply and sanitation services at affordable cost. Initially the project will rehabilitate the existing water and sewage infrastructure to the original designs while the second phase will augment the extension of the networks to the unserved areas. In total both phases will cost about 20 million euros (Ksh. 180 million). The project has pro-poor components as it is addressing the problems of water and sanitation for the informal settlements. It is hoped that such projects when completed will go along way in mitigating the pollution problem of Lake Victoria.

1.1.3.2. Fisheries resources

1.2.3.2.1. Capture fishery

Fisheries constitute one of the most important resources of the lake, with a production value estimated at $550 million and an export value of $250 million. The fisheries contribute significantly to the GDP of the riparian countries; with a contribution of 0.5%, 1.5%, and 1.8% of the GDP in Kenya, Uganda and Tanzania respectively. The Lake Victoria fishery is also important for employment with about 180,000 fishers and about 600,000 fish traders directly employed in the three countries. With an average dependency ratio of 8:1, this means that about 7 million people depend directly or indirectly on the fisheries. Additionally, many more people both within and out of the basin depend on fish for food. Among the critical issues in fisheries leading to unsustainable exploitation are excess effort and use of destructive gears and methods.

1.2.3.2.2. Aquaculture production

Aquaculture still contributes just about 1% of the total fish landed in Kenya, and its growth has largely stagnated over the last decade. The main candidate fish species for aquaculture in the Lake Victoria basin are: *Oreochromis niloticus, Tilapia zillii and Clarias gariepinus*

1.1.3.3. Agricultural production

1.1.3.3.1. Crop production

Agriculture production is also one of the mainstays of the lake region economic base. For instance agriculture contributes about 24% of the Gross Domestic Product (GDP) of the country while in Lake Victoria basin, it contributes 75% of the basins labourforce and supports a livelihood of upto 90 % of the inhabitants. There is a large diversity in agricultural potential of lake basin, with some land being of high agricultural potential while other parts are medium and low potential with some parts being marginal, arid or semi-arid land.

Cash crops within the Lake Victoria basin are targeted to supplement income from subsistence farming where food crops have long been the focus of attention. It is estimated that most households rely on subsistence farming as an alternative to other livelihood pursuits. Food insecurity in the region could be attributed to declining involvement of households on subsistence farming within the lake basin catchments. More efforts should also be devoted into identifying other crops appropriate for the five agro-ecological zones within the lake basin. The main crops include tea, maize, sugar cane, banana, millet, coffee, pyrethrum, tobacco, potatoes, cassava, rice and a wide variety of indigenous and exotic fruits and vegetables. In addition to these crops, there is need to diversify to high value crops such as Vanilla, Jatropha and Mushrooms.

1.1.3.3.2. Livestock production

Livestock is kept as a form of wealth accumulation and a fall back when money is needed for medical and education expenses. The main livestock kept is dominated by Zebu with an estimated population of 1.5 million cattle. These animals are kept on a communal (free range) grazing basis. In the recent past the exotic breeds of cattle numbers are increasingly being kept in place of the indigenous breeds. In addition the Rift Valley province and Kisii areas have significant numbers of cross breeds. Goats, sheep, pigs and pultry are also kept.

1.1.3.4. Wetland resources

The main wetlands in Lake Victoria basin include Yala swamp, Nyando, Sondu Miriu, Oluch Kimira (Mogusi) and Gucha. Other smaller wetlands within the basin include Saiwa swamp (on the Nzoia river), Murula swamp (Eldoret) and Dionosoyiet in the vicinity of Kericho as well as seasonal floodplains. Wetlands in the Lake Victoria provide a variety of goods and services including building materials, mats, fisheries resources, buffering of pollutants and act as habitats for wild life, etc. However, the wetlands are under threat from drainage and agriculture conversion.

1.1.3.5. Forest resources

The Lake Victoria basin has about 460 000 ha of gazetted forests (i.e. plantations, natural forests) which is distributed as follows; Mt Elgon (73 000), Cherangani Hills (53 000), Kakamega Forest (23 000), Nandi Forest (30 000), Tindiret Mau (210 000), Ilkerin – Lolgorian (60 000) and Gwassi Hills (12 000). Forests contribute siginificantly to the basin's economy by providing wood and non-wood forest products for commercial and domestic use. For instance, they support the pulp and paper industries, sawmills, the building and construction industry, charcoal production, firewood, transmission posts for telephone lines, and woodcarving. They also facilitate income-generating activities such as beekeeping by providing an anchor for beehives. Forests are a wildlife sanctuary, harboring a host of animals, birds and insects all of which are tourist attractions. Some tree and plant species are important as medicine or food. Specific areas are gazetted as protected forest areas however, the acreage is diminishing as more forest land is taken up for settlement and cultivation.

Forestry is a revenue-generating sector however, all fees and royalties collected by the central government are submitted to the central treasury. Fees and revenues collected by regional district, and other local authorities may be retained at those levels to finance general government expenditures. In overall national economic planning forestry is accorded low priority in comparison to other sectors such as health, education and agriculture.

The existence of a permanent forest estate is essential for the long-term planning and management of natural forests, whether the particular management objective is timber production, conservation of biological diversity, watershed management or multiple use management. Their existence depends on the political will to protect

these forests against logging. Some areas of the forest have been excised for tea estates or other agricultural purpose, for example, Kakamega forest.

Communities living adjacent to forests have significant impact on forest conservation, use and management. Large areas of forest cover outside the gazetted forests are managed and used by such communities. Local communities also make heavy use of gazetted forests. Community members often enter the forests illegally to secure timber for building firewood, materials for woodworking and other artisanal crafts, fruits and nuts, medicinal plants, and game and fish. Some communities have traditionally protected forests as sacred or ritual sites, or as water sources.

The most criticial issues in forestry management and conservation include;

a) Forestry is not well integrated into larger land use policiesas well as in the environmental policies.
b) Protection to maintain integrity of forests is lacking
c) Protection to conserve biological diversity in the forests is lacking
d) The legislation to support transboundary control of forests is lacking
e) Forestry regulations are inadequate.
f) Royalties and fees in forestry are low
g) Ban on logging in indigenous forests
h) There is no mechanism in place to certify forestry products that are produced.

1.1.3.6. Mining resources

Mining contributes about 2% of the National Gross Domestic Product. In the lake basin, mining takes place in isolated areas, however, its contribution to the basin economy has not been determined. Gold has been the main industrially mined mineral in the basin, however, most of the major identified gold mines, for example, in Migori and Kakamega districts, have been fully exploited and there is little industrial mining now taking place. Other minerals are copper, base metals, rare earth elements, Kisii soapstone, phosphate, sulfur, Wollastonite and nephelinite, manganese, tin, kaolin, clay, flourspar, iron ore, graphite, sheltie, diatomaceous soil, and building material (limestone, granite, brick clay, sand, tuffs, murrum and material for ballast). Industrial mining of limestone continues at Koru in Nyando District. Some artisanal mining takes place, especially for gold, and the extraction of building material, such as granite, brick clay, sand, tuffs, murrum and material for ballast. There is need for increased exploration for new mineral deposits that may be commercially exploited.

1.1.3.7. Energy resources

The main sources of energy in Kenya are wood fuel, electricity and oil. Nationally, wood fuel accounts for 70%, while oil and electricity constitute 20% and 9% of Kenya's energy consumption respectively. The Lake Victoria basin has a large potential for hydroelectric power. According to the LBDA Masterpan (1987), the basin has the potential to generate 563 megawatts (MW) of hydropower as follows; Nzoia river, 159; Yala, 114; Nyando, 14; Sondu Miriu, 249 and Kuja Migori, 27 MW. Currently, in the lake basin hydro-power electricity generation is limited, although this will expand with the full implementation of the Sondu-Miriu Hydro-power project.

Other potential energy sources such as solar, geothermal, currents, wave and wind energy are not significantly developed. Wind power is used mainly to pump water in a few parts of the basin and to propel sail boats in the lake. Hot springs are present in parts of the basin, but these have not been exploited for energy. Similarly conversion of solar power to electric energy is least exploited.

1.1.3.8. Tourism in Lake Victoria basin

The Lake Victoria basin is endowed with a variouty of sceneries with huge potential as nature tourism and ecourourism sites. Some of the important and famous gazetted National Parks, such as Masai Mara, Mt. Elgon and Ruma are within the lake basin. In addition other tourist sites include Kakamega forest, Impala Park and Ndere Islands in the vicinity of Kisumu as well as the agrorice schemes such as the Ahero Rice Scheme, the sugar belt (Muhoroni, Chemelil, Miwani, South Nyanza) and Kericho and Nandi Tea Estates. However, the immediate Lake Victoria circuit (the so-called 'Western Tourist Circuit') is perceived to be of high tourist potential, though, still not well developed. Efforts to develop tourism in the region should target; the beautiful landscape, the people, sacred and cultural sites (for example 'Nyamgondho' in Suba District and 'Thim Lich Ohinga' in Migori District), pre-historic sites (for example palaentological sites in Rusinga Island), pre-colonial fortified sites; indigenous forests (for example, in Kakamega); the lake, islands, and lake resources (including ornamental fish); wild game, including insects (for instance, butterfly in Kakamega Forest) and numerous natural features (including famous rocks such as 'Kit Mikayi' in Kisumu District) and hot springs (in Rachuonyo District). There are also Museums maintained by the National Museums of Kenya, for example in Kisumu and Kitale (Mt Elgon), which are an integral part of the tourist circuit. There is need to improve the infrastructure, provision of services and amenities for the tourist industry to develop.

1.1.3.9. Wildlife resources

The wildlife resources within the basin are represented by migratory and residential bird populations, large mammals such as the Elephants, Lions, Buffaloes, Cheeter, Hippopotamus, and the small mammals such as Otters as well as reptiles such as crocodiles and monitor lizards and amphibians. The basin has been designated as an Important Bird Area (IBA) with 70 IBAs such sites in the basin. Some of the endangered bird species are found in the basin. These are mainly the vulnerable Papyrus Yellow Warbler *Chrolopeta gracillostris* and Papyrus Gonolek *Laniarius mufumbiri.* The Sitatunga (*Tragelaphus spekei*) currently one of the endangered species is a largely aquatic animal and uses the wetlands in most of the times as a habitat and feeding ground.

1.1.3.10. Trade and industry

Trade and Industry accounts for 50% of Kenya's GDP and is the fastest growing sector of the economy with the highest number of employment opportunities (GOK 2003). Kenya's trade deficit widened to KSh 212.3 billion ($2.995 billion) between January 2005 and January 2006. The imports totalled KSh 440.2 billion ($6.204

billion) against exports of KSh 227.9 billion ($3.209 billion) over that period (The Standard 4 May 2006). The overall balance of payment turned out a surplus of $530 million in the year ending January 2006 compared with $275 million up to December 2005 and $293 million up to November 2004. The economic growth for 2005 stood at 5.3 per cent compared to 4.3 per cent in 2004. It is anticipated that for the year 2006 the growth targets 5.5 per cent. The annual inflation rate dropped to 14.9 per cent in April 2006 compared to 19.3 per cent in March 2006. The inflation had risen sharply from 3.9% in October 2005 to 19.1 in March 2006 (The Standard 4 May 2006).

The riparian states remain Kenya's biggest trading partners. Trade between Kenya, Uganda and Tanzania has greatly increased since the integration of EAC started about a decade ago. Kenyan exports to the EAC grew at the rate of 55% annually from Ksh. 36.5 billion in 2001 to 66.7 billion in 2005. Exports to Tanzania grew at the rate of 62 percent annually from Ksh. 11.1 billion in 2000 to 19.9 billion in 2005 while exports to Uganda grew at the rate of 65% annually from Ksh. 24.2 billion in 2000 to 42.5 billion in 2005. Imports to Kenya from Tanzania also grew at the rate of 20.4 percent annually from Ksh. 549 million in 2000 to 2.9 billion in 2005. The Uganda imports to Kenya grew by 49.2 percent annually from Ksh. million in 2001.

There is no data on the volume and value of transboundary trade within or across the Lake Victoria basin. However, judging from the movement of goods within and out of the catchment it is obvious that trade plays a very important role in the local economy both as a source of income, employment and food. Most of the trade within and across the basin is on agricultural and livestock products, fisheries products, other food products, non-agricultural household goods, farm inputs, wood and timber products, clothes and textiles, construction materials etc.

1.1.4. Transboundary transport infrastructure

The main means of transboundary transport are by road, water and air. There is presently no cross-border rail transport in the region, however, there are long-term plans to revive the East African rail network. Road transport is mainly through the main international transit routes passing through the official border posts, for example; Nairobi-Kisii-Isebania, Nairobi-Kisumu-Busia, Nairobi-Eldoret-Malaba and Busia-Kisumu-Isebania. There are also numerous smaller roads or tracks across porous borders. It has been recommended that a ring-road be developed to run along the Kenyan shoreline, joining most fish landing beaches, which would greatly improve communication and fish trade. Transboundary public road transport vehicles include buses, mini-buses and small vans, while there are numerous smaller private cars and larger vehicles transporting goods, including oil tankers. The road infrastructure in the lake basin is, however, one of the least developed in Kenya, particularly in the area immediately around the lake. Most roads in the area are not permanent, made mainly of murram and gravel, which require very frequent maintenance. Many of these roads are impassable during the rainy seasons, causing serious disruption on movement of people and goods and imposing huge costs on providers of transport services.

Another emerging type of public road transport is by bicycle taxi, popularly known as 'boda boda'. These are found in nearly all the major towns and rural centres, contributing significantly to employment of young people. The bicycle transport is

now a major, though informal, player in the transport sector in both urban and rural centres. The bicycle taxi services extend to the major transboundary areas, including the official border posts and the unofficial cross-border routes in the region. The main problems facing bicycle transport are; lack of rules and regulation, no bicycle tracks, high rates of accidents, operators not trained on traffic regulations etc.

The lake water is a medium of transport especially for communities living around the lake and in several islands within. There are several small passenger and goods transport boats operating very informally in the lake with hardly any regulation and a few large regional cargo transport vessels operated by the national Railways and Harbour Corporations in the three countries. However, there is little data and information available on the volume and value of this transport industry. The main problems in relation to water-based transport are; lack of regulation, high rates of accidents, no disaster preparedness, poor facilities and services.

Air transport is limited to the main cities, and connects the two main airports in Eldoret and Kisumu to the outside world, via Nairobi. Eldoret Airport is fully fledged international airport, however, the location and altitude makes it less attractive to potential users. It has been indicated that the Kisumu Airport is more strategically located and can attract much larger volume of business. Therefore it is recommended that Kisumu Airport should be upgraded to an international airport, which will necessitate additional investment in upgrading the infrastructure, facilities and services. Kisumu airport is a potential means to drive the growth of the fish and horticulture export industries in the region. However, due to their central location, the airports do not sufficiently serve the needs of the greater Lake Victoria basin. In particular, the fish industry has not benefited from the airports, instead preferring to transport fish to Nairobi and Mombasa by road for export.

1.1.5. Climatic change and variability in the lake basin

1.1.5.1 Impacts of climate change

The different impacts of climate change are drought, floods, hurricanes, cyclones, tsunami, increased cloud cover and precipitation. Changes in climate can induce long-term, low-grade and cumulative or short-term and abrupt alterations to the environment and alter the abundance, distribution and availability of fish, livestock and range animals. Climate variability may cause variation in the farming seasons, hence affecting crop production, leading to decreased agricultural production. Climate variability may also interfere with the regeneration of animal populations by affecting the survivorship function (recruitment, age, size, growth) and migration patterns of animals. Climate change may further lead to decline in primary productivity, alter the catch composition and species abundance of fish populations by having uneven impacts on production and may influence estuarine, lacustrine and riverine processes. Climate variability may also lead to changes in the traditional migration routes of fish.

In addition, climate change may lead to change in the availability of economic resources, shift in economic activities, change in economic costs and market responses. Depending on the economic, political and social setting; climatic change

may lead to flexibility in the socio-economic and political structures, introduce flexibility in regional arrangements or laws and regulations; and induce resource conflicts. Climatic change may lead to a shift in population numbers through movement from a disaster area, or in extreme circumstances, cause death of human beings and livestock. Adverse climatic conditions induce disaster and impact differently. Severe drought lead to reduction in lake levels as has been experienced in the recent past. Long periods of dry spell may lead to deaths of game animals and livestock as has been experienced (Daily Nation, 28 March 2006). Heavy rainfall can be equally devastating leading most rivers to swelling their banks and displacing thousands of the lake basin residents (Daily Nation, 26 March 2006). Within the Lake Victoria basin, climate variability and change has certainly contributed to the current condition of Lake Victoria. The lake's status has apparently been influenced by the global warming trend evident in the high-elevation tropics as well as increased particulate organic matter in the water column. The driving mechanism seems to be anomalously high sea surface temperatures in the tropical ocean persisting for at least 30 years, about the time frame during which Lake Victoria has experienced its most dramatic changes. The Lake is now 0.5℃ warmer than in the 1960s, in harmony with changes in surface temperature at tropical elevations above 1000 m worldwide (Lehman, 1997). Changes in radiative heat transfer functions have led to elevated water temperatures, while slackened winds have caused less intense mixing, enhancing the anoxic conditions in the hypolimnion.

1.1.5.2 Mechanisms of coping with climatic variability

Societies have different capacities to deal with environmental changes that are climate-related. It is important to understand the socio-economic and political setting at the time of environmental change. The degree of dependence of a community or a country on the commercial exploitation of a particular resource could be the key to understanding the major determinant in the resolution of a conflict over the resource. It is also important to understand the role of regional scientific and political organizations in dealing with the consequences of environmental changes and their preparedness to cope with the resource-related changes. In order to project further on the understanding of climate change and climate variability there is need to forecast ecological consequences based on climate change; rates of climate change of the causal links to various potential responses by individuals, populations, economic sectors and the ecosystem; and effects of climate change on the biogeochemical processes and climatic interactions.

1.1.6. Resource use conflicts

In the Lake Victoria basin, human pressures on natural resources are increasing, while many resource bases are deteriorating or being depleted, creating an increased potential for competition and conflict between groups within societies. Among the resources that have sources of contention leading or contributing to conflict in the distant or recent past are fresh water, productive land, fisheries, and mineral deposits. In addition, as environmental pressures rise, the quality of certain resources and natural products, such as fresh water, fisheries yields, and forest products, are becoming an important issue connected with scarcity.

1.1.6.1. Conflicts in manifestation stages

In the recent past, the Lake has witnessed conflicts in resource use including; cattle rustling, access rights, cross-border fishing, water use, wetlands degradation, forest destruction, human and wildlife and increased incidences of bush fires. Clearing of forests has resulted in deforestation, a dominant feature in most parts of the lake zone where land is bare following the expansion of settlements, livestock keeping, and agriculture and prize variability across borders. Other types of conflicts include social conflicts arising from poverty, lack of employement, drug abuse etc.

1.1.6.2. Conflicts in latent stages

There are also conflicts in opinion regarding management, conservation and use of natural resources between various groups, for example; scientists versus political leaders, fisheries managers versus fisheries biologists, politicians versus politicians and between different groups of resource harvesters. Ultimately this affects decisions and strategies on how resources are utilized, with the result that it is often difficult to reach a consensus among different and competing interest groups. The degree of dependence of a community or a country on the commercial exploitation of a particular resource could be the key to understanding the major determinant in the resolution of a conflict over the resource. Sources of conflicts in resource use involves scientists vs political leaders, fisheries managers vs fisheries biologists, politicians vs politicians, group harvesters vs another (Glantz & Feingold 1992).

1.1.6.2. Suggestions for conflict resolution

The following measures are considered crucial in conflict resolution

(i) Sectoral harmonization (Institutional harmonization, linkages and coordination))
(ii) Development of harmonized fishing regulations
(iii) Fishers to acquire legal fishing equipment and education on cross border regulations
(iv) Regular crossborder meetings
(v) Harmonized tax regimes and prizing of commodities
(vi) Development of Memorundum of Understanding (MOU) between various institutions

1.1.7. Health status in the lake basin

1.1.7.1. Human health

The lake basin faces serious challenges in health and socio-economic development. At the lake's shores the incidence of malaria is amongst the highest in the world, closely followed by HIV/AIDS. Other diseases affecting the lake communities include; bilharzia, intestinal worms, sleeping sickness, diarrhoea diseases and Rift Valley fever. According to the 1999 Kenya National Population Census, the lake basin has very high infant mortality rate, with about 90 children out of 1000 expected to die before reaching the age of 5. The life expectancy in the lake basin stands at

49.2 years for males and 55.2 years for females. Both figures are lower than the national average, which stands at 52.8 years for males and 60.4 for females. The mean age in the lake basin is quite low, at 16.8 years, compared to 18.3 years national average. Unemployment rates are quite high in the basin where only 19.7% of the population is in active employment compared to 27.9% national average. The major human diseases are; HIV and related illnesses (HIV/Aids, Tuberculosis, Upper respiratory infections, Meningitis, Pneumonia, Anaemia), Vector-borne diseases (Malaria, Schistosomiasis, Trypanosomiasis), Water-borne diseases (Typhoid, Cholera, Amoebiasis).

1.7.1.2. Animal health

The most common animal diseases within this region are Trypanosomiasis, East Coast Fever, Anaplasmosis, Babeosis, Heartwater, Newcastle disease, Foot and mouth disease, Rift Valley fever, Rabies, etc. Livestock diseases have been the major challenges to pastoralism. Wild animals are a major factor in the spread of these diseases. The concentration of livestock within relatively smaller areas means that diseases can spread quickly. Livestock movement is identified as one mechanism for the spread of diseases and as a constraint, which makes control and eradication very difficult (Moyini, 2004). Thus, the situation could be improved by separating domesticated animals from bush animals and by vaccination. In the recent past much media publicity has been given to the avian influenza (H5N1), however, there have not been any confirmed cases in the lake basin.

1.1.8. Management of Lake Victoria basin as a shared ecosystem

The Rio Earth Summit in 1992 stimulated the interest for joint management of Lake Victoria and its basin as a shared ecosystem. The Lake Victoria Environmental Management Project Phase 1 (LVEMP-I) was prepared and implemented from 1994 as part of this initiative. Other initiatives included the creation in 2001 of the Lake Victoria Development Programme (LVDP) at EAC Secretariat, and more recently, the development of a Protocol for sustainable management of Lake Victoria basin, which provides both for the detailed legal framework and a Lake Victoria basin (LVBC) Commission as a body for the regional management of the entire basin (EAC, 2003). As a result of the establishment of the East African Community and subsequent formulation of an East African Development Strategy (2001-2005), the Lake Victoria basin has been designated an economic growth zone, with the potential to develop into a major economic region (EAC, 2003). The Lake Victoria basin development is also highly influenced by political factors.

1.1.9. Legal and Policy Issues Relevant to the Lake Victoria basin

At the global level and in Kenya, there is growing concern that development activities have the potential to cause severe damage to the environment, including the natural resource base on which the economies are based. The major challenge facing stakeholders and government today is how to institute sustainable development that protects the environment at the same time. The legal and regulatory settings of the Lake Victoria basin state the approach to preserving the environment of its catchment. The existing legal and regulatory mechanisms may provide barriers and

mechanisms to sustainable resource utilisation and effective environmental management. In this respect, the following pertinent aspects of the legal regime are considered crucial. These are: Legal and Regulatory Mechanisms of the Use and Protection of the Environment and Natural Resources of the Lake Victoria basin, Bilateral Agreements, Regional Agreements, Compliance with International Environmental Conventions and Institutional Frameworks.

Currently the three riparian countries do not have an agreed policy for the overall management of Lake Victoria. The national water resources, agriculture and livestock and forestry policies of all three riparian countries do not pay particular attention to the issues of lake management or transboundary water resources management. Instead, that function has been assigned to the recently revived East African Community (EAC) organization representing Kenya, Tanzania and Uganda. Management is sectorally based with little coordination among sectors. Of the sectors fisheries management is probably the most coordinated, partly because of its importance to the economy of the riparian countries and partly because of the external assistance provided to this sector. Activity in this sector was galvanized following the ban of Nile perch imports into the European Union (EU) because of poor hygienic conditions in the industry. Improvements in lake-wide fisheries management occurred because of the shock that all riparian countries felt when earnings from a major export commodity were threatened. Other aspects of lake management are nationally based and uncoordinated. There are no agreed baseline against which management actions can be judged, no common lake management protocol and no common water quality or discharge standards. The lack of transboundary water quality standards makes it impossible to ensure that remedial actions undertaken by one government will be effective and sustainable. Even a uniform set of data to describe the state of water quality in the lake has not been assembled from the separate national data collection efforts. Thus, there is no baseline from which to measure changes in the status of the lake's environment or from which coordinated management activities can be based.
In summary, the main policy constraints are in relation to;

a) Lack of coherence of sectoral policies
b) Conflicting policies
c) No regional harmonization of most policies
d) Lack of sufficient protocols and treaties
e) Conflicts between institutions implementing similar policies in different sectors
f) Weak policy enforcement capacity

1.1.10. Community involvement in the management of lake basin resources

Community-level involvement in management of Lake Victoria is most advanced in the fisheries sector. As a result of the LVFRP and LVEMP, beach management units have been established in all riparian countries to provide local ownership for enforcing fisheries rules to avoid overexploitation of the fish stock. Legislation is being prepared to support their activities in each country. Also fishing communities have been successfully engaged in raising and releasing beetles for water hyacinth control. Both activities show the power of community-level initiatives when the outcomes clearly directly affect the livelihoods of those communities. However, this level of involvement has not been achieved with catchment communities in reducing the loads of sediment and nutrients reaching the lake from surface sources. The

East African Communities Organization for the Management of Lake Victoria (ECOVIC) and OSIENALA are some of the most prominent non-governmental organizations (NGOs) in the Lake Victoria region. There are a very large number of Community Service Organizations (CSOs) and NGOs active in the region although not necessarily involved directly in lake management issues. It is estimated that about 40 NGOs in the lake region are concerned with environmental issues. However, there appears to be no long-term mechanism for community level involvement in the lake basin management after these transient donor supported investments are completed. The proposed Lake Victoria Basin Commission (LVBC) would provide an important vehicle for this input.

1.1.12. Conservation and development initiatives in Lake Victoria basin

Among the regional initiatives that have been implemented in the Lake Victoria basin in the past decade include; Lake Victoria Environmental Management Project (LVEMP), Improved Land Management in the Lake Victoria basin, The Lake Victoria Fisheries Research Project, Implementation of a Fisheries Management Plan of Lake Victoria, Nile Equitorial Lakes Subsidiary Project. These initiatives are discussed below;

1.1.12.1. Lake Victoria Environmental Management Project (LVEMP)

LVEMP-I and other bilateral efforts have developed and accumulated significant knowledge and technical capacity to enable assessment of the environmental stresses confronting the Lake and its catchment. Additional research on key issues enabled setting of objectives and prioritisation of actions for management of the Lake and its resources. This was done in a participatory manner to ensure that local community interests and concerns were appropriately reflected. The next step will be to harmonise the objectives and prioritised actions with the other riparian states and then get endorsement by EAC Secretariat. The success of this venture should bring out a broad vision of the riparian peoples' desire for Lake Victoria in the future, to ensure sustainable use of the resources of lake and its tributary waters.

The implementation of LVEMP-I met a number of challenges, especially since it involved several sectors and institutions with diverse interests aiming to achieve specified objectives in a relatively short time frame. Despite this, LVEMP–I made significant achievements in a number of areas. In overall, LVEMP-I has resulted in improved ability in the riparian States to embark on a long-term program of resource management and environmental improvement. Among the achievements of LVEMP-I include; undertaking studies in fishery biodiversity, aquaculture potential and water quality/limnology. Pilot projects were also implemented on soil conservation, catchment afforestation, wetlands management, and several community micro-projects. Among the immediate impacts of LVEMP-I were; reduction by 85% in the surface coverage of water hyacinth in the Lake through biological, manual and mechanical control; improved beach sanitation, reduction in soil erosion and increase in forest cover.

A second phase of the project, LVEMP-II, has been identified through a process involving review of performance of LVEMP-I and formulation of a Vision and Strategy

Framework for the management and development of Lake Victoria basin. The above processes culminated into a Regional Stakeholders Concept Workshop, which identified the priority areas of focus for LVEMP-II as;

(i) Socio-economic Development
(ii) Management framework
(iii) Applied Research.

The rationale of the TDA has been to collate, identify and analyse available transboundary environmental concerns that would be addressed in LVEMP-II. TDA has identified the key drivers contributing to the environmental degradation and pointed out the environmental hotspots. It has created a benchmark for further monitoring of the health of the Lake Victoria basin ecosystem. This process has been undertaken within the framework of the Nile Basin Initiative (NBI) and provided a basis for the formulation of recommended options for improving the environmental situation and ensure the sustainable development of the Lake Victoria basin. This also is intended to stimulate the formulation of interventions that are responsive enough to the social, economic and ecological challenges – perceived, emerging or real.

1.1.12.2. Improved Land Management in the Lake Victoria Basin (TransVic)

The project "Improved land management in the Lake Victoria basin (TransVic)" was initiated in July 1999 between the then NSWCP (National Soil and Water Conservation Programme) of the then Ministry of Agriculture and Rural Development and the World Agroforestry Centre (ICRAF) with finance from the Swedish International Development Agency (SIDA). In July 2000 a three-year phase of the project began under the new National Agriculture and Livestock Extension Programme (NALEP), again with funding from SIDA. The first phase of NALEP has been extended one year and now is due to be completed in June 2004. NALEP is implemented by the Ministry responsible for agricultural extension – the Ministry of Agriculture and Rural Development until January 2003, the Ministry of Agriculture and Livestock Development until May 2003, and most recently the Ministry of Agriculture. The purpose of the TransVic project is to provide extension providers, policy makers and researchers with information, methods, technologies and approaches for improving land productivity while enhancing local and regional environments.

1.1.12.3. The Lake Victoria Fisheries Research Project (LVFRP I &II)

The project was funded by the European Union and implemented in two phases (LVFRP-I and LVFRP-II) from 1989-2002. This was a regional project with KMFRI as the implementing institution in Kenya. The main objectives of the project were to assist the newly established Lake Victoria Fisheries Organization in the creation and initial functioning of a viable management framework for the fisheries of Lake Victoria, creation and development of the knowledge base required for the rational management of the fisheries of Lake Victoria.

1.1.12.4. Implementation of a Fisheries Management Plan of Lake Victoria (IFMP)

This project has a 5-year implementation period from 2003-2008. The main objectives are; to contribute to the sustainable economic growth, resource use and development in the Lake Victoria basin with an aim is to sustain fish stocks in the lake, as well as helping governments to monitor catches and stamp out illegal fishing.

1.1.12.7. Nile Equitorial Lakes Subsidiary Project (NELSAP)

The Nile Equitorial Lakes Subsidiary Project (NELSAP), under the umbrella of the Nile Basin Initiative, has identified several regional projects in the Kagera river catchment (to involve Burundi, Rwanda, Uganda and Tanzania), Sio Malaba Malakisi river basins (to involve Kenya and Uganda and Mara river basin (to involve Kenya and Tanzania). The main objective of these initiatives is to promote poverty alleviation, economic growth and the reversal of environmental degradation in the Nile equitorial lakes sub-basin.

Other government and non-governmental institutions which have contributed to the management of the resources of Lake Victoria include: Lake Victoria Regional Local Authority Cooperation (LAVLAC), ECOVIC, OSIENALA, Nile Basin Discourse Forum and Network of Environmental Journalists for Lake Victoria. The major authorities around Lake Victoria including; Mwanza, Kisumu, Kampala and Jinja constitute the membership of LAVLAC. The main activities undertaken under these forums include; awareness creation, and lobbying for sustainable management of Lake Victoria resources. IUCN-EARO and Sida Sweden played a vital role in mobilizing and sensitization of the NGO networks.

1.2. Global objective of transbounday diagnostic analysis

The main objective of this study was to prepare a Transboundary Diagnostic Analysis (TDA) of the Lake Victoria basin in order to identify a Strategic Action/Investment Program (SAP) addressing key environmental issues and poverty alleviation by promoting sustainable economic growth.

1.2.1. Specific objectives

a) Provide structured information relating to the degradation and changing state of the Lake Victoria basin.
b) Identify and evaluate the major environmental problems that face or may face the Lake Victoria basin and to determine their root causes.
c) Scale the relative importance (prioritization) of the causes and sources of the transboundary problems.
d) Identify the cause-effect chain underlying the identified problems, and to determine their relationship with the deterioration of the basin's water resources.
e) Identify practical preventative and remedial actions that will enable sustainable management of the Lake Victoria basin resource.

The TDA has been prepared on the basis of previous studies of the physical and geographical features, land use, water uses, and the socio-economic and environmental situation in the lake basin that extends into the territories of the five riparian countries (Kenya, Tanzania, Uganda, Rwanda and Burundi).

SECTION 2. STUDY METHODOLOGY

This section discusses the methods used for carrying out this TDA particularly for data collection and analysis. It explains the scope of TDA including the subject and geographical scope.

2.1. Scope of Work

The scope of conducting this TDA involved several tasks, which included: desk reviews, field surveys, data analysis and identification of the major perceived problems and issues (MPPI). The work was accomplished in two main stages, the inception phase, which involved preliminary assessment of data and information and the main phase in which further and more detailed data generation analysis and reporting were done.

2.2. Desk Review and Field Surveys

Data and information was mainly generated through desk review of relevant literature, information gathering through questionnaires and interview of stakeholders as well as the validation of the main findings and the acquisition of new information through conducting various local and national meetings and workshops. This was a starting point for detecting the most salient transboundary elements of the environment in the lake basin. The consultants visited several institutions and libraries and held meetings with various researchers to assess, review and compile data and information. Field visits were made to primary stakeholders, including; fishermen, farmers, foresters and people living in wetlands and other vulnerable areas in the lake basin.

2.3. Data Analysis and Identification of MPPI

Analyses of information generated and formulation of remedial measures as required in a TDA process. The identification of the major perceived problems and issues (MPPI) was the first step in the TDA process and constituted the justification for the subsequent in-depth analysis.

The following information was required to address each MPPI;

a) Knowledge about each problem/issue
b) Data supporting the quantification of the extent of the problem
c) Based on available data, whether these are real problems and issues or just perceptions

These questions assist in developing a status assessment. Subsequently, a causal chain analysis is undertaken for each Major Perceived Problems and Issues (MPPI) through field surveys, stakeholder workshops to determine the root, primary and secondary causes. Participatory Rural Appraisal (PRA) is used to prioritize MPPI.

2.4. Global International Waters Assessment (GIWA) model

In implementing this TDA, the Global International Waters Assessment (GIWA) model was used. It consists of scaling, scoping, causal chain analysis and policy options analysis.

a) *Scaling* involves the identification of boundaries and systems mostly by recognizing the ecological zoning or geographical zoning. The activities within the boundaries of targeted areas can then be grouped as shoreline, immediate hinterland and upper/middle reaches.
b) *Scoping* is the identification of critical concerns and issues with their impacts.
c) *Causal Chain Analysis* is the identification of the driving forces/root causes of transboundary concerns.
d) *Policy Option Analysis* indicates potential policy interventions that could mitigate, and if possible, eliminate environmental problems.

The analysis recognises that people commonly act across a number of somewhat independent sectors (agriculture, industry, transport, fisheries etc.), which are usually poorly coordinated and often have conflicting interests. Thus, the stakeholders may work in an uncoordinated and sometimes conflicting fashion, but they typically affect the aquatic environment in similar ways.

The guidelines by the Global Environmental Facility (GEF) recommend that a stakeholder analysis be performed in support of the TDA. The analysis should involve all the stakeholders such as; institutions, organisations, ministries, and industry related to the perceived problem and issues. The information pertaining to this list includes the effect of the issue on stakeholders, the nature and effectiveness of the interactions between the stakeholders as well as their strengths and weaknesses in view of their actual and/ or potential role in managing water and water dependent resources.

2.5. Participatory Rural Appraisal (PRA)

Participatory Rural Appraisal (PRA) has been used in this TDA study to prioritize the MPPI from the perception of the main primary sector groups such as fishers, farmers and women groups. PRA describes a range of techniques for participatory research, learning and action. PRA is a process of learning about rural conditions with emphasis on tapping local knowledge, and using a range of methods specifically selected to enhance understanding of local conditions or prioritize issues, problems and solutions. PRA aims for greater stakeholder participation and puts emphasis on involvement of the community in the appraisal process.

The PRA techniques used in this assessment included

a) Semi-structured interviews: This PRA technique is used to ask questions and probe issues, particularly to get in-depth understanding of the causes of problems and possible solutions.
b) Matrices: This PRA technique is used to establish and rank relationships between perceived problems and their causes or with possible solutions.
c) Pairwise ranking: This technique compares perceived problems pairwise (two at a time) to come up with an overall chart of prioritized issues.

2.6. Spatial Scope of TDA

Following the GEF guidelines and TDA framework approved by Ramsar in May 1998, TDA should cover the entire water catchment and as far out of the lake as possible. However, in general, TDA distance should concentrate between 100 km and 200 km. The rivers have to be addressed with their upper and lower reaches as a priority. Taking this recommendation, this TDA study covered the area as defined by the Lake Basin Development Authority (LBDA) shown in Figure 1.1.

However, the geographic scope or scale for some MPPI may extend. For instance, lake level decrease may be caused by factors global in nature and thus the appropriate geographic scale is the globe, while many processes specific to lakeshore desertification (poor land use planning, poor agricultural practices etc.) may be limited to the lakeshore units. Pollution also has a much broader scale than defined by Ramsar since rivers may bring pollution from all portions of the drainage basin. In case of river systems the TDA should be limited to the proximate discharges of the water and associated pollutants possibly extending to the river's lower reaches and the littoral zone.

SECTION 3. SITUATIONAL ANALYSIS

This section provides a brief introduction to the environment of Lake Victoria and its catchments. The physical description of the lake provides a context within which to understand the major perceived problems and issues.

3.1. Physical and Biogeochemical Characterisitics of Lake Victoria

3.1.1. Physical setting of Lake Victoria

3.1.1.1. General description of the Lake Victoria basin

Lake Victoria, the second largest fresh-water lake in the world, is shared by three East African countries, with Tanzania having 49%, Uganda with 45% and Kenya with 6% (4,128 km^2). The Lake has a surface area of 68,800 km^2, at an altitude of 1134 m above sea level and touches the Equator on its northern reaches (Table 3.1). Its near-rectangular coastline extends from 2.5 °S to 0.5°N and from 31.5 to 34 °E, thus being approximately 400 km long by 250 km wide (Figure 3.1). Its only major outlet is the River Nile, which is the longest river in the world. The lake is relatively shallow, reaching a maximum depth of about 79 m, and an average depth of about 40 m. Lake Victoria is a vital resource on which about 30 million people in the riparian countries are dependent. The lake provides major ecosystem services namely; high biological diversity (many endemic fish species), fringing wetlands and floodplain vegetation. The lake basin is used in the riparian communities as a source for food, energy, water, building materials and transportation as well as a repository for industrial and domestic waste.

Table 3.1: Morphometric and hydrological data for Lake Victoria (after Bootsma and Hecky 1993)

	Lake Victoria
Catchment area (km^2)	194,200.00
Lake area ((km^2)	68,800.00
Maximum depth (m)	79.00
Mean depth (m)	40.00
Volume - V- (km^3)	2,760.00
Outflow (%)	24.10
Inflow (%)	18.10
Precipitation (%)	81.90
Evaporation (%)	75.90
Flushing time (years)	140.00
Resident time (years)	23.00

3.1.1.2. Origin and geology of Lake Victoria basin

Lake Victoria straddles the equator, perched high on the African craton in tectonic sag between the two rift valleys of East Africa. The lake is thought to be relatively young, formed through tectonic forces over 400,000 years ago (Yisong *et al*. 2004; Johnson *et al.* 2000). Most of the lake is surrounded by Precambrian bedrock, with the exception of the Kavirondo Gulf in the northeastern corner. Tertiary and Recent alkali volcanic and sedimentary units dominate the terrain. Three major desiccation

events are recorded in the seismic records that may reflect the 100,000-year Milankovitch cycle of climate forcing. The lake has suffered periods of complete desiccation and sometimes pluvial flooding escapades. The most recent arid period resulted in complete desiccation of the pre-existing lake. Primary production was extremely high as lake level rose in its first 500 years, nourished by the high input of nutrients from the flooded landscape.

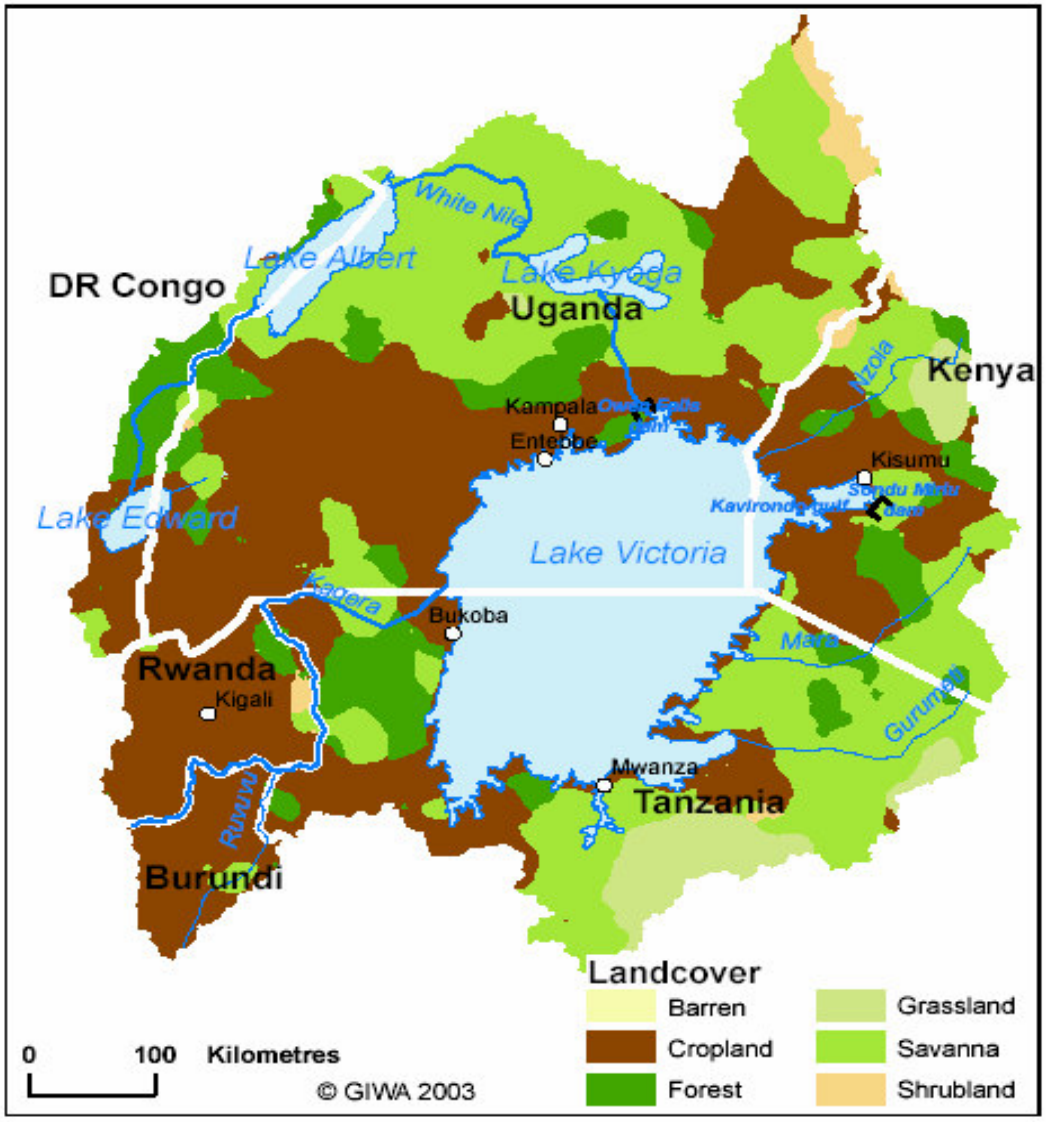


Figure 3.1 Map of Lake Victoria basin showing the land cover (Adapted from Odada *et al. 2004*)

3.1.1.3. Bathymetric characteristics of Lake Victoria

The river drainage patterns and exposed lacustrine sediments to the west of Lake Victoria reveal the lake's origin: a result of uplift along the western branch of the East African Rift Valley in late Pleistocene time, and back ponding of rivers that previously

had drained westward. Uplift and tilting of the basin is continuing today, resulting in a drowned morphology characterized by highly irregular northern, eastern, and southern shorelines of the lake and a continuing eastward shift in the center of the lake basin (Figure 3.2).

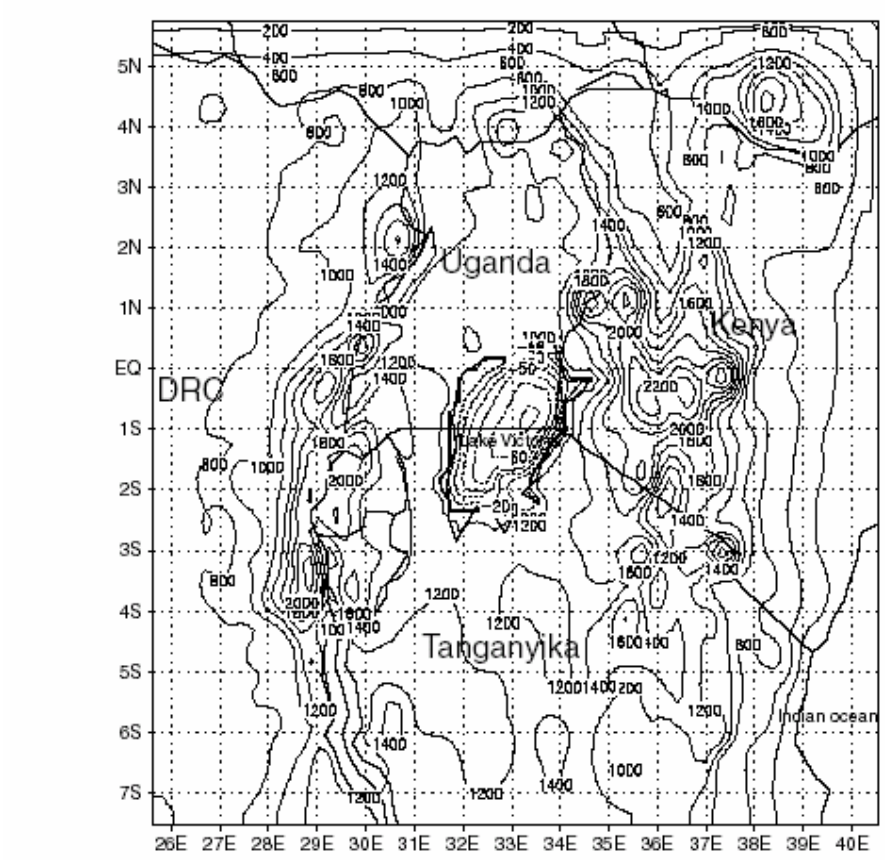


Figure 3.2 Land surface topography and Lake Victoria bathymetry data**.** Bathymetry is measured in terms of depth below Lake surface. Units in metres

3.1.1.4. Characteristics of the Lake Victoria coastline

The lake has diverse geographic features, which are mostly shallow (< 40m) deep. The catchment has several rivers, streams, satellite lakes and wetlands all interconnected. The shoreline of 3,460 km long is convoluted, enclosing many bays and inlets. The Kenyan portion of the lake has a shoreline of 760 km. The lake has over 100 Island clusters such as Ukerewe, Sesse, Mfangano, Ringiti, Buvuma, Sigulu. There are critical habitats in specific parts of the lake, rivers, streams and swamps, satellites lakes in which fishes and other biota congregate for specific needs.

3.1.1.5. Contemporary water level fluctuations

The lake water budget is regulated by rainfall, catchment river inflows, evaporation and River Nile outflows. Changes in these components will either raise or lower the

lake level. In the recent past, the lake level has fallen as a result of a combination of two factors, namely;

a) reduced input in terms of rain and inflows into the Lake, and
b) Increased outflows caused by excess releases at Jinja.

In the years 2003 and 2004 the lake has dropped by 77%, with over 50% occurring in 2004 alone (Figures 3.3, 3.4). The general absence or limited rains on the lake in recent years resulted in reduced lake levels by 1.64 m between 1998 and November 2004, with the year 2004 having been severely hit by this shortage of input. Current information indicates that the inflow from the rivers decreased by 14.8% in that period (Mngodo *et al*. 2005).

Increased outflows have been associated with power generation at Owen Falls Dam. Reports indicate that excess releases accounted for 45% of the total fall in the period 2001-2004. The summary of flow characteristics for River Nile outflow indicates an increase in average flow out of the lake by 15% to 1057.6 Cumecs in the period 2001-2004 as compared with the long term average of 1046 Cumecs in the period 1950-2000, including the per cent of all losses, with the remaining loss being evaporation (Table 3.2).

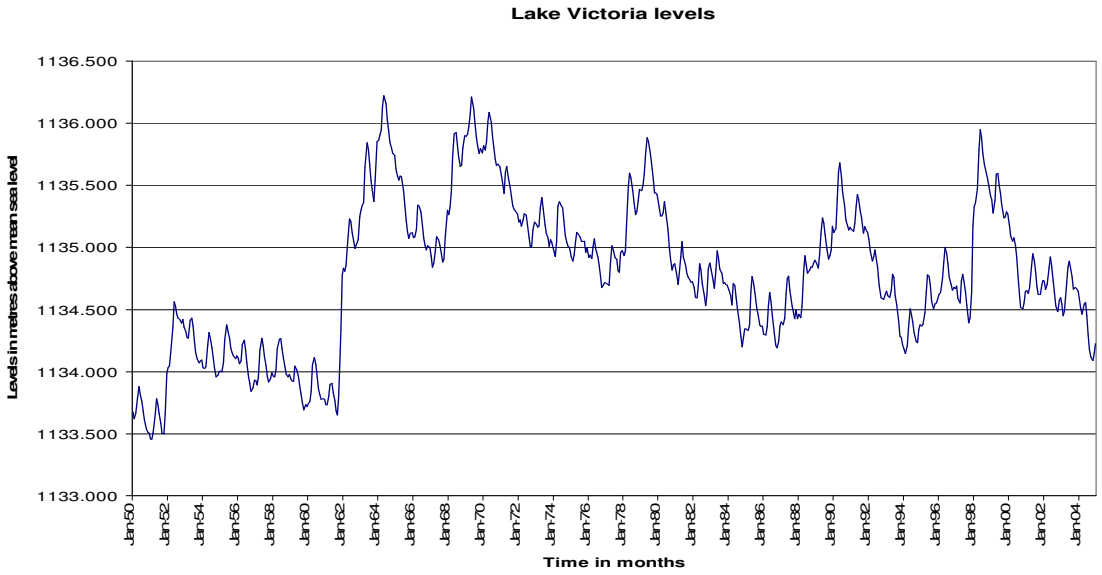


Figure 3.3 Evolution of the lake levels as recorded at Jinja (COWI 2002)

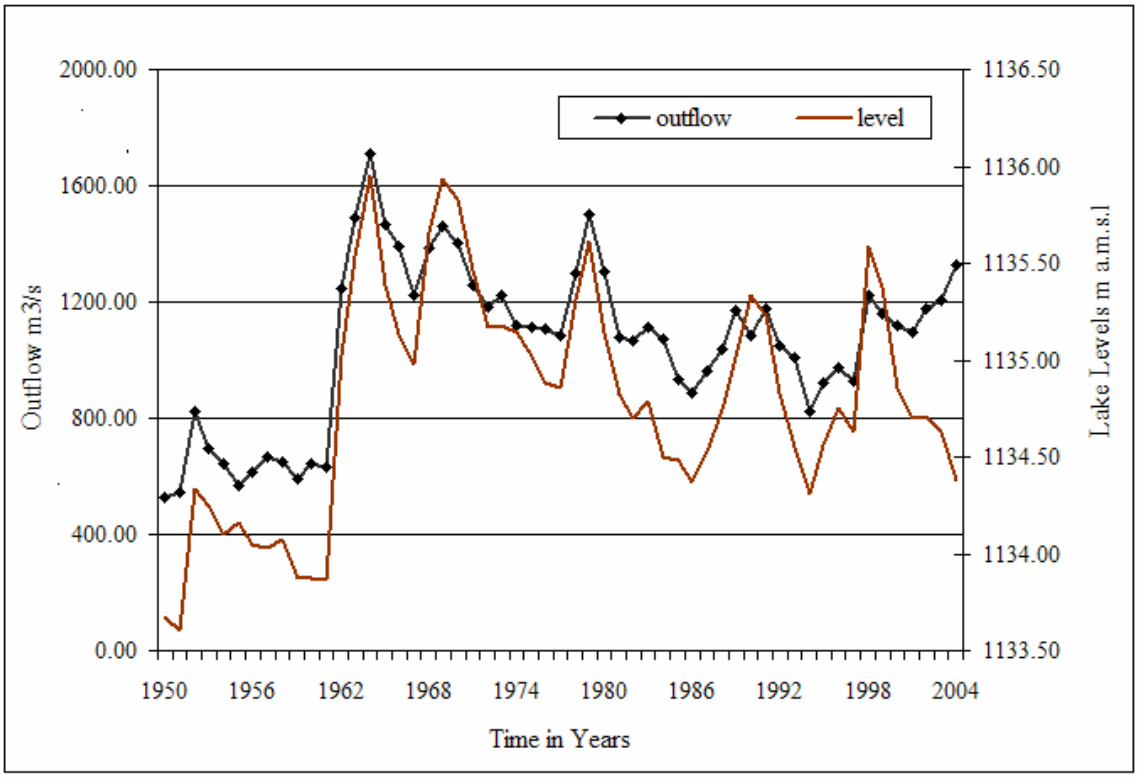


Figure 3.4 Lake level and outflow through the White Nile at Jinja (Adapted from Mngodo *et al.* 2005)

Table 3.2 The evolution in the water balance of Lake Victoria (Adapted from Mngodo et al. 2005)

Process	1950-2000 Flow m^3/s	%	2001-2004 Flow m^3/s	%	1954-2004 Flow m^3/s	%
Inflow						
Rainfall	3611.50	81.80	3644.00	84.20	3613.80	81.90
Basin discharge	805.30	18.20	686.20	15.80	796.60	18.10
Out flow						
Evaporation from the lake	3329.80	76.10	3337.50	73.50	3330.30	75.90
Victoria Nile	1046.20	23.90	1 201.90	26.50	1057.60	24.10
Sum	**40.78**		**-209.24**		**22.59**	

3.1.1.6. Circulation patterns and currents in Lake Victoria

Reports show that there is rarely any recognisable large-scale circulation pattern in the lake (COWI, 2002). The currents are weak (less than 0.1 m/s) and frequently in opposite directions at adjacent stations. Similarly, the winds rarely show any consistency in speed and direction from station to station. Furthermore, there is little correlation between the wind and the surface current speeds and directions. Based on the available data, the preliminary conclusion is that, for most of the year there

does not seem to be any recognisable large-scale horizontal circulation pattern in Lake Victoria.

3.1.1.7. Rivers draining the lake basin

The main rivers from the Kenyan catchment are Rivers Sio (trans Kenyan-Ugandan boundary), Nzoia, Yala, Nyando, Sondu-Miriu, North Awach, South Awach and Kuja Migori. From the Tanzania catchment, the main rivers are Mara, Grumeti, Eastern shore streams, Mbalageti, Simiyu, Magogo, Isanga, southern shore streams, Biharamulo, Western shore streams, Kagera and Bukora. In the Ugandan Catchment the main rivers are Katonga and the northern shore streams (Figure 3.5 and Table 3.3). The most significant of these rivers, the Kagera contributes about 33 percent of the total inflow, or over a half of that over and above direct precipitation.

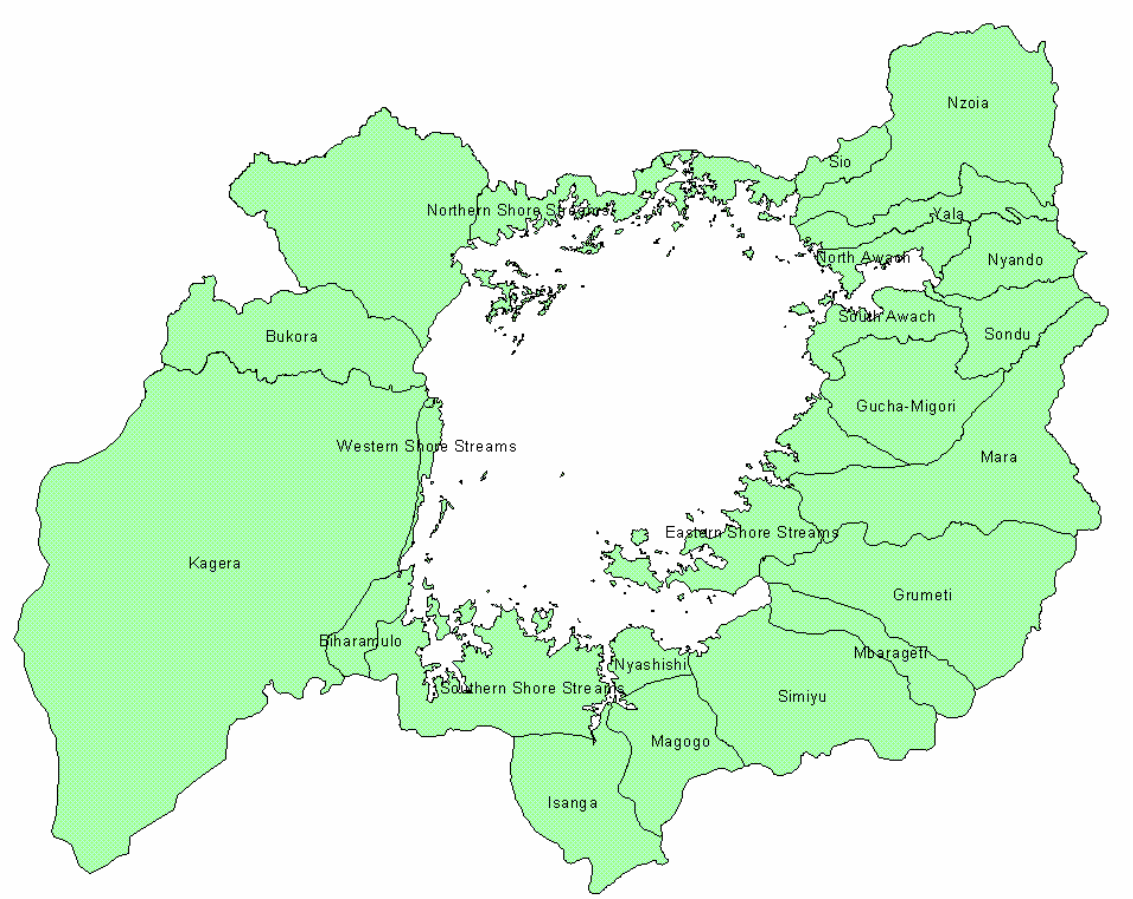


Figure 3.5 River basins in the Lake Victoria catchment (Adapted from COWI, 2002)

About 75.9 percent of the water leaving the lake does so through direct evaporation from its surface, and the remaining 24.1 percent largely by way of the Victoria Nile, which leaves the lake near Jinja in Uganda, and flows via the Owen Falls, Lake Kyoga, and the Murchison Falls to join the outflow from Lake Albert; these two outflows are the main sources of the "White Nile". In total the water budget indicates a positive inflow of 33 $m^3 s^{-1}$ (Table 3.4).

Table 3.3 Long-term average discharge from river basins in Lake Victoria catchments (COWI, 2002)

Country	Basin	Discharge (m^3s^{-1})	Percent
Kenya	Sio	11.40	1.50
	Nzoia	115.30	14.80
	Yala	37.60	4.80
	Nyando	18.00	2.30
	North Awach	3.70	0.50
	South Awach	5.90	0.80
	Sondu Miriu	42.20	5.40
	Kuja Migori	5.80	7.50
Tanzania	Mara	37.50	4.80
	Grumeti	11.50	1.50
	Mbalageti	4.30	0.50
	East shore streams	18.60	2.40
	Simiyu	39.00	5.00
	Magogo Maome	8.30	1.10
	Nyashishi	1.60	0.20
	Issanga	30.60	3.90
	South shore streams	25.60	3.30
	Biharamulo	17.80	2.30
	West shore streams	20.70	2.70
	Kagera	250.90	33.50
	Bukora	3.20	0.40
Uganda	Katonga	5.10	0.70
	North shore streams	1.50	0.20
Total		**778.30**	**100**

Table 3.4 Average inflows to and outflows from Lake Victoria (Data from COWI, 2002)

Average 1950-2000	Flow (m^3s^{-1})	Percentage
Inflows		
Rain over the lake	3631.00	82.00
Basin discharge	778.00	18.00
Outflows		
Evaporation from the lake	-3330.00	76.00
Effluent (Victoria Nile)	-1046.00	24.00
Balance	33.00	

3.1.1.8. Surface water temperature of Lake Victoria

Temperature values range from 24.08 ºC in the south to 27.26 ºC in the northern zones. The southern portion of the lake is generally colder than the north and north

eastern parts of the lake (Figure 3.6). This is associated with the presence of suspended organic matter from the inflowing rivers which trap sunlight resulting in elevated temperatures. The northern portion of the lake is also shallow as compared to the southern zone and thus, sunlight penetrates to the bottom.

About 82 percent of the water entering the lake originates from precipitation directly onto the lake surface; the remainder (18 per cent) is contributed by rivers, which drain the surrounding catchment (Table 3.4). The most significant of these rivers, the Kagera, contributes roughly 33 percent of the total inflow, or over a half of that over and above direct precipitation.

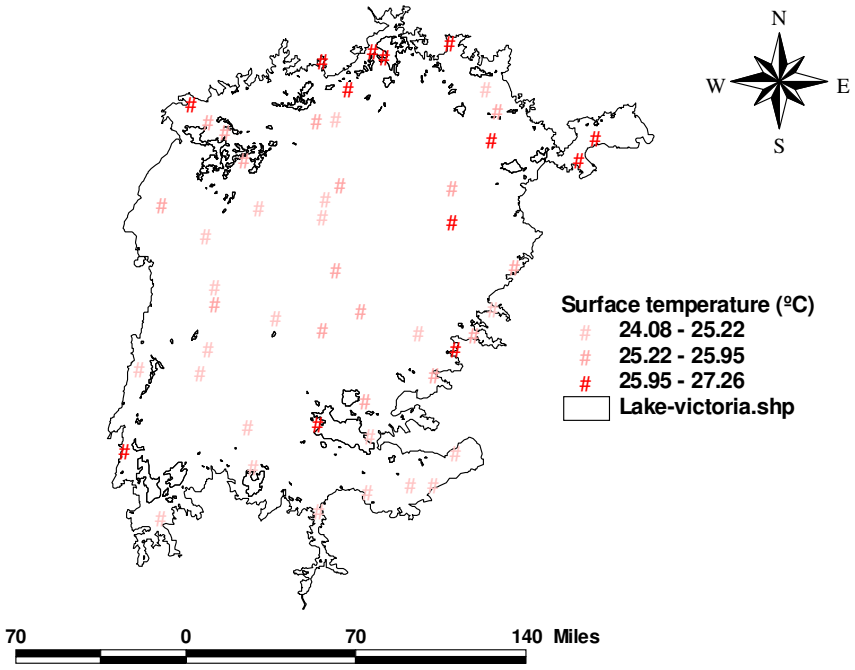


Figure 3.6 Spatial variations in surface water temperatures in Lake Victoria (Data from IFMP reports, 2005)

3.1.1.9. Climatic conditions of Lake Victoria basin

Many studies have investigated the variability of the Eastern Africa climate (Mukabana & Pielke, 1996; Lehman, 1997; Yin & Nicholson, 1998; Semazzi & Song, 2001 and references cited therein). The seasonal climate over the Lake Victoria basin is primarily governed by the passage of the Inter-Tropical Convergence Zone (ITCZ) that separates the northeast and southeast monsoons (Nicholson *et al.*, 1996a). The ITCZ crosses East Africa twice every year, once during March to April–May and again during October–November–December. This incursion and retreat of the ITCZ is responsible for the two main rainfall seasons and dry seasons of the region. The rainy season of March through to May is commonly known as the 'long

rains'; the second rainy season of October through to December is called the 'short rains'. Observational studies (Asnani & Kinuthia, 1979) and numerical studies (Indeje & Anyamba, 1998) have associated the observed afternoon hail and thunderstorm activities over the western parts of the Kenya highlands with the interactions between the prevailing easterly flow and the diurnal mesoscale circulations in the region.

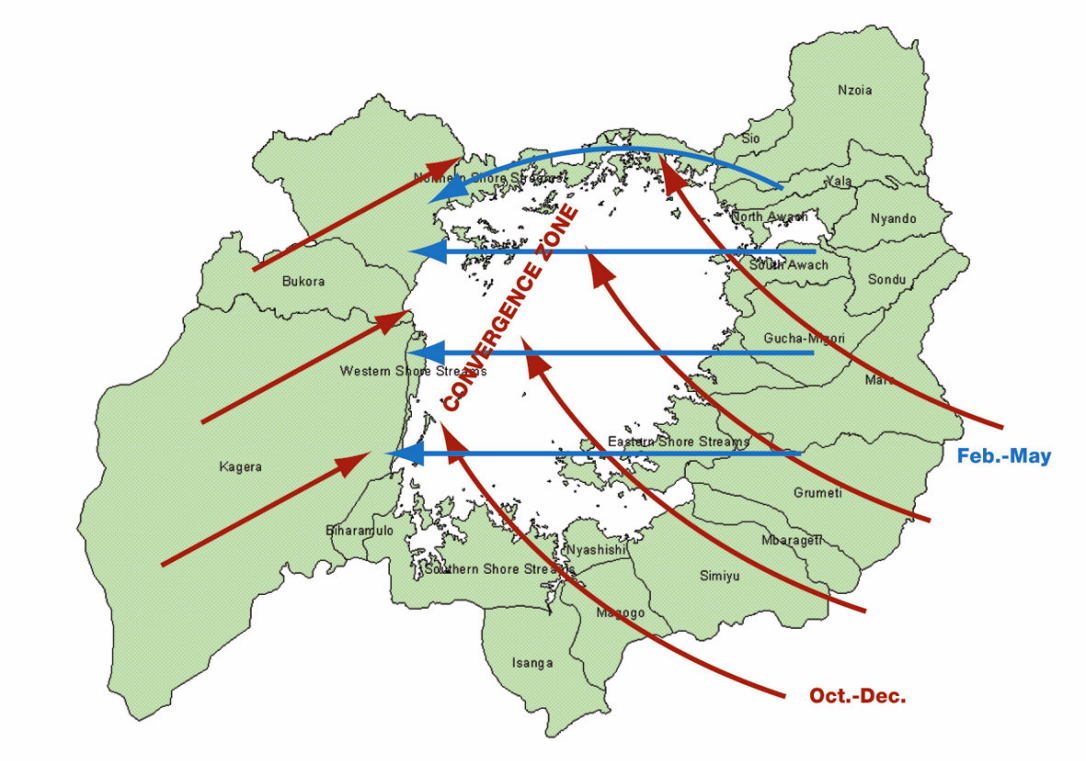


Figure 3.7 Global wind patterns over Lake Victoria (From COWI, 2002)

From October to December the wind approaches the lake from southeast and, as they cross the lake, they turn more towards the north (Figure 3.7). At the same time there is a wind stream from Congo approaching the lake from southwest. These two wind streams meet in a convergence zone along the western side of the lake. As the wind crosses the lake from southeast, it picks up more moisture and deposits it as rain in increasing amounts from east to west. The rainfall intensity reaches a maximum in the convergence zone. From February to May the main global wind flow is from east to west. Again, the air increases its moisture content from east to west and the rain intensity increases in the same way.

3.2. Environmental quality

3.2.1. Water quality status in the Lake Victoria basin

The beginning of the slow deterioration of Lake Victoria ecology is very much linked to the rapid riparian population growth and consequent livelihood activities associated with farming and urbanization. Multiple activities in the lake basin have increasingly come into conflict with the lake's ability to cope. Despite a 7-fold

reduction in soluble reactive silica in the water column, diatoms have increased their biomass since the 1960s in Lake Victoria (Kling *et al*. 2001).

Industries mainly located in the larger towns bordering the lake are: Kampala and Jinja in Uganda, Mwanza and Musoma in Tanzania and Kisumu in Kenya. Exceptions are the larger sugar factories in Kenya located at some distance from the lake. According to COWI (2000) these focal areas, which are associated with cities in the three countries (Kisumu, Mwanza and Kampala), received 57% of the total BOD load to Lake Victoria, 9% of total Nitrogen and 22% of the total Phosphorus (atmospheric deposition excluded). The study showed that the main point sources (industrial and municipal) were concentrated at a few major cities in Uganda and Tanzania, while in Kenya; the main point sources were distributed at several large towns. Table 3.5 presents an overview of the industrial production of the region. Although in Tanzania and Uganda industrial wastewater treatment facilities are generally absent, a majority of Kenyan factories does operate a treatment plant. Although treatment efficiencies are generally low, their effect should not be neglected. Much of Ugandan industrial effluents furthermore drain through wetlands before reaching the lake surface water.

Table 3.6 shows the pollution loads from the main gulfs of Lake Victoria. The results suggest that these gulfs namely; Mwanza Gulf, Murchison Bay, Napoleon Gulf, Winam Gulf and around Kisumu areas are the major hot spots of pollution loading into the lake.

Table 3.5 Estimated production of the major industries in the catchment area of the lake (From Scheren *et al*. 2000). Number in parenthesis indicate the number of factories sampled. – No data

	Shared production of the major factories -t yr-1		
Industry	**Kenya**	**Uganda**	**Tanzania**
Slaughter houses	3000.00 (1)	14 000.00 (3)	-
Dairy factories	-	25 000.00 (1)	-
Fish factories	18 0000.00 (6)	12 000.00 (4)	6630.00 (2)
Vegetable oil refineries	-	3 300.00 (2)	31 400.00 (4)
Sugar factories	640 000.00 (6)	-	3 500.00 (1)
Distilleries	18 000.00 (1)	460.00 (1)	-
Breweries	60 000.00 (1)	17 000.00 (1)	-
Bottlers	41 000.00 (1)	40 0000.00 (2)	11 100.00 (1)
Cotton mills	1500.00 (1)	-	1320.00 (2)
Leather industries	270.00 (1)	60.00 (1)	220.00 (1)
Paper mills	94 000.00 (1)	-	-
Soap factories	-	40 000.00 (2)	15 000.00 (1)

Table 3.6 Nutrient loads for Winam Gulf, Mwanza Gulf and Murchison Bay (From Scheren *et al.* 2000). – No data

Focus area	Source	BOD (tons/year)	Total nitrogen (tons /year)	Total phosphorous (tons/year)
Winam Gulf	Catchment	-	2327.00	547.00
	Atmospheric Deposition	-	-	-
	Industrial	455.00	3.00	1.00
	Municipal	3908.00	664.00	294.00
	Total	**4, 363.00**	**2 994.00**	**842.00**
Mwanza Gulf	Catchment	-	556.00	101.00
	Atmospheric deposition	-	-	-
	Industrial	2 838.00	289.00	185.00
	Municipal	3815.00	520.00	208.00
	Total	**6653.00**	**1375.00**	**494.00**
Murchison Bay	Catchment	-	-	-
	Atmospheric deposition	-	-	-
	Industrial	781.00	53.00	45.00
	Municipal	1512.00	389.00	267.00
	Total	**2 293.00**	**442.00**	**312.00**

Among the three riparian countries, Kenya is economically the most developed one and therefore it is one of the riparian countries that export more pollutants. In addition most of the rivers originate from Kenya and these are the major conduits for the pollutants. Although Kenya has rather strict pollution laws, these are rarely enforced because the industries have ties with foreign investors and the Government often has a significant stake in the polluting units. Moreover, it is considerably cheaper for the industries to pay an occasional US$220 fine than to install equipment to treat effluent at a cost of US$2 million. In general it is (Scheren *et al.* 2000) calculated that through efficient management of existing treatment facilities only BOD loads in Kenya could be reduced by 50%. Out of the industries-breweries, sugar cane factories, soap and oil factories displayed the largest load.

3.2.2. Status of eutrophication in Lake Victoria

Runoffs from the tropical rains carry both excess of nutrient as well as soil into streams that run into the lake. Formerly the wetlands fringing the lake acted as natural filters to trap silt and extract nutrients, but these wetlands have been greatly reduced and thus, allowing the silt and nutrients to enter the lake. Marked increases in the inputs of phosphorous, nitrogen and silt have taken place, particularly in the later decades of the twentieth century. Stimulated by these nutrients phytoplankton growth in the lake waters has been phenomenal. Gross phytoplankton production (PP_G) is a product of the phytoplankton biomass (chl), the euphotic depth (Zeu) and the photosynthetic irradiance parameters (P_{BM} and aB). Overall, gross phytoplankton production has increased through eutrophication supporting high fish biomass (Figures 3.8, 3.9).

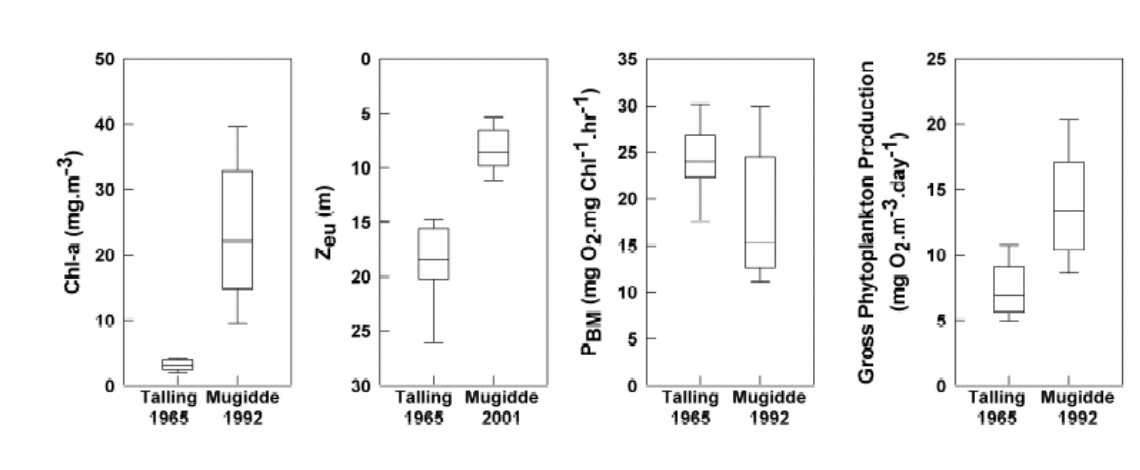


Figure 3.8 Gross phytoplankton production (PPG) in Lake Victoria expressed as a product of the phytoplankton biomass (chl), the euphotic depth (Zeu) and the photosynthetic irradiance parameters (P_{BM} and aB

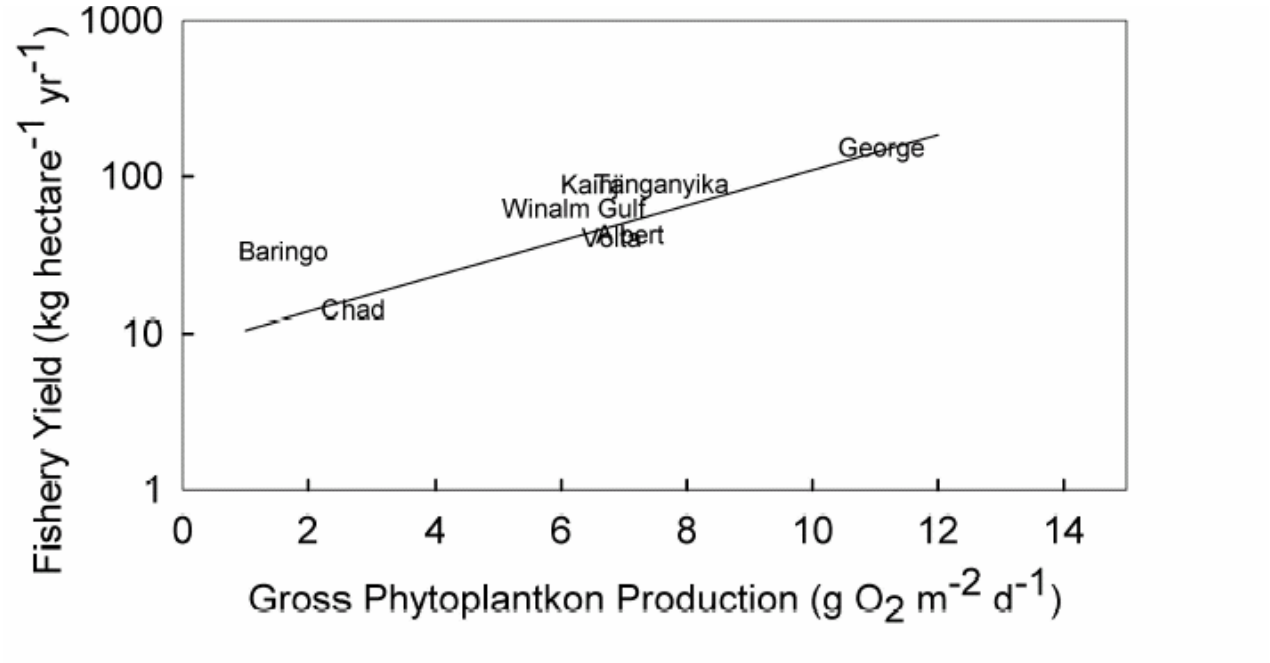


Figure 3.9 Gross primary production as a function of fish yields

3.2.3. Levels of contaminants in the Lake Victoria basin

The use of persistent organic pollutants (POPs) in the lake basin dates back to the 1960s when a campaign was launched to use them to eradicate malaria. The main POPs are; DDT, Aldrin, Chlordane, Dieldrin, Dioxins, Endrin, Furans, Heptachlor, Hexachlorobenzene, Mirax, Polychlorinated BiphenylsToxaphene. In addition other pesticides in use in the basin include; acaricides, fungicides and herbicides (Table 3.8). DDT, Dieldrin and Benzene hexachloride have been used since the 1950s for malaria control. By 1960s the uses of POPs for Malaria control had spread to 65

countries with a combined population of about 737 million people. As a result the mosquito species quickly developed resistance to these pesticides. The insecticides proved to be persistent with unwanted side effects to human health as well as killing non-target species, for instance bees. Garden crops contained unwanted residues of DDT, while it was also detected in the milk of cows that grazed on sprayed fields. Past research has revealed that the POPs can also act as endocrine disrupters, interfering with the body's hormones and affecting health. The effects include; birth defects, sexual abnormalities and reproductive failures in human and wildlife. The most important of these is the decline in the male sperm count. Other defects include hormone related cancers and endometriosis. In 1972, the US Environmental Protection Agency (EPA) banned the use of DDT, while the pesticide was banned in Kenya in 1986. In the recent past Uganda has lifted the ban on the use of DDT. Table 3.10 lists the banned pesticides while Table 3.11 shows pesticides that were imported into Kenya between 1986 and 2002. The key observations with regard to contaminants as outlined in LVEMP-1 Synthesis (2005) are;

a) Banned organochlorine pesticide compounds are still being used in the catchments.

b) There were high concentrations of the compounds in soil where they were directly applied. They were also detected in water and sediments from rivers which drain through the farming areas, and that their concentration in water was influenced by their concentration in soil and sediments and rain played a major role in the transportation process through surface run-offs. Their presence in the soil for up to five years since last application shows that the pesticides also persist in tropical soil conditions (Table 3.7).

c) The levels of lead, cadmium, nickel, iron and copper in fish muscle from Kisumu Bay of lake Victoria are within the acceptable limits of the Kenyan and international standards for marine and fresh water animal products (Table 3.8). The levels of the heavy metals in water were lower than the levels found in fish muscle, which shows the accumulative concentrations of the heavy metals in fish muscle. Need to cite studies of Campbell *et al.* (2003) in regards to Hg in fish in Winam Gulf and risks associated with Hg.

d) River Kisat has relatively higher values than lake water and this is attributed to the fact that River Kisat serves as a sink for industrial and sewage waste from Kisumu Town.

e) As heavy metals biomagnify in aquatic food chains, the risk for possible poisoning if people eat contaminated fish increases. Accumulation and biomagnification of heavy metals in fish can pose health risks. Burning of vegetation containing heavy metals can lead to their presence in the atmosphere that is absorbed in water. Levels of heavy metals in water and the food chain are currently low, however, there is need to keep monitoring and prevent processes that may increase their concentration in the environment (Table 3.9 gives recommended rates of agrochemicals).

Table 3.7 Heavy metal concentration (ppm) in fish muscle and water from Kisumu Bay. (T = Tilapia, W = Water, MF = Fish muscle, NP = Nile perch).

Station	Sample	Pb	Cd	Ni	Fe	Cu
Dunga point	T	1.30	0.12.	1.67	0.72	0.05
Dunga Point	NP	1.22	0.09	1.18	1.03	0.04
Dunga Point	MF	1.36	0.11	1.60	0.85	0.05
Hippo Point	T	1.37	0.12	1.77	0.99	0.05
Hippo Point	NP	1.32	0.11	1.63	0.22	0.04
Hippo Point	MF	1.50	0.15	2.00	1.00	0.08
Police Pier	MF	1.68	0.12	1.41	0.08	0.12
Otonglo Point	MF	0.10	0.02	0.03	1.45	0.02
Dunga Point	W	0.15	0.01	0.09	0.07	0.01
Hippo Point	W	0.23	0.01	0.08	1.04	0.01
Shell Power	W	0.19	0.01	0.07	5.60	0.01
Police Pier	W	0.13	0.02	0.02	1.50	0.01
Otonglo Point	W	0.09	0.01	0.07	0.15	0.00
Kisat River	W	1.21	0.08	0.04	5.73	0.05
Standard Bureau of (Kenya)		10.00	10.00	10.00	10.00	10.00
Standard (WHO)		5.00	5.00	5.00	5.00	5.00

Source: LVEMP Synthesis Report (2005)

Table 3.8 Agro-chemicals used in the Lake Victoria catchment

Type of Culture	Fertilizers	Insecticide/ Acaricides	Fungicides	Herbicides
Maize	CAN, DAP, UREA (Nitrate)			
Rice	DAP, CAN	Furadan, Carboduran		
Tea	CAN, ASN, NPK (25.5:S), NPK (20:20:0), NPK (26:6:12), FOLIA FEEDS, UREA	Fenitrothion, Dimethoate, Diazinon, Karate	Copper-Zinc Spray, Dithane, M45(Mancozeb), Marshal, Miltraz(metalaxyl&propinep), Ridomil(metalaxyl)	Round up (Glyphosate), Touch Down, Gramoxone (Paraquat), Afalon, 2-4D Amine (72%)
Sugar Cane	NPK, CAN, UREA			Round up, Diuron, Nata, Kombi
Coffee	NPK (20:20:0) NPK (7:17:0)	Diazinon, Dasis Fenitrothion, Fenthiom	Copper Nordox, Kocide 101 Dithane, Antracol, Copper-Oxychloride	Round up
Horticulture	DAP	Diazinon, Ambush, Doom Powder, Karate, Dimethoate	Dithane super, Milruz Ridomyl, Mithane Super Acrobat, Antracol, Sancozeb Samcozide	
Cattle	ACARICIDES (Triatix, Delnav DFF, Steladone, Almatix			

SOURCE: Farmers and DALEO Offices- Nandi, Kericho and Nyando Districts

KEY:

DAP =Diamonium Phosphate $(NH_4)_2HPO4$ SSP=Single Superphosphate
TSP=Triple Superphosphate CAN =Calcium ammonium phosphate
NPK =Nitrogen Phosphate potassium ASN=Ammonium Sulphate nitrate

Table 3.9 Main agrochemicals used in the Lake Victoria basin

AGROCHEMICAL	CROPS USED ON	RATES AND REMARKS
Urea-Fertilizer	Sugar and occasionally Rice	50-100 kg top dressing, used in splits
CAN-Fertilizer	All Crops	50-120 kg per top dressing, used in splits
DAP and NPK-Fertilizer	All Crops	75-150 kg per ha. Basal application
Karate	Tomatoes, Kales, Cotton	750-1000 litres per ha.
Milraz	Tomatoes	30-50 gm/20 litres
Dithane M45/Mancozeb	Tomatoes	30-50 gm/20 litres
Actellic Supper	Cereals-Maize + Sorghum	100gm per 90 kg bag on storage pests
Dimethoate	Vegetables, Fruit tree, tobacco	25-50mls/20lts, 0.75-1,5 litre per ha. In a number of trade names
Ridomil	Tomatoes	180gm/20 litres, 500-1000 gm/ha
Milthane	Tomatoes	180gm/20 litres, 500-1000 gm/ha 1-1.5 kg per ha.
Furadan 5G	Rice and Hort.nursery	1-1.5 kg per ha.
Kocide	Coffee	2-2.5 kg per ha.
Dipterex	Maize and sorghum	1 kg per ha
Linulon	Sugarcane	Herbicide upto 5 kg per ha.
Round up	Sugarcane	Herbicide upto 3-5 kg per ha.

SOURCE: District Agriculture Office Nyando (NYD/SUP/VOL.I98).

Table 3.10 List of banned or restricted pesticides in Kenya

No	Pesticide	Use	Status
1	Dibromochloropropane	Soil fumigant	Banned
2	Ethylene dibromide	Soil fumigant	Banned
3	2.4.5.-T	Herbicide	Banned
4	Chlordimeform	Insecticide	Banned
5	Mixture of isomers of Hexachlorocyclohexane (HCH)	Insecticide	Banned
6	Lindane (pure y-BHC (HCH))	Insecticide	Restricted use for seed dressing only
7	Chlordane	Insecticide	Banned
8	Heptachlor	Insecticide	Banned
9	Endrin	Insecticide	Banned
10	Aldrin	Insecticide	Restricted for termite control in building industry
11	Dieldrin	Insecticide	Restricted for termite control in building industry
12	Toxaphene (Camphechlor)	Insecticide	Banned
13	DDT	Insecticide	Restricted use to Public Health only for mosquito control in mosquito breeding grounds, banned for agriculture use
14	Captafol	Fungicide	Banned-1989
15	Parathion methyl/Parathion ethyl	Insecticide	Banned-1988
16	Daminozide (Alar)	Plant growth regulator	Voluntary withdrawn by the company
17	Cyhexatin (Plietran)	Acaricide	Voluntary withdrawn by the company

Nos 1-13 banned in 1986
SOURCE - Pest Control Products Board Box 14733, Nairobi, Kenya.

Table 3.11 Pesticides imported into Kenya in the last 16 years (in percentages)

YEAR	Insecticides/ Acaricides	Herbicides	Fungicides	Others	TOTAL
2002	57.10	11.40	28.40	3.10	100.00
2001	52.50	7.60	22.90	17.00	100.00
2000	50.60	13.70	32.40	3.30	100.00
1999	47.00	10.30	35.50	7.20	100.00
1998	38.40	16.70	43.60	1.20	100.00
1997	48.40	12.50	34.40	4.70	100.00
1996	47.70	13.20	35.60	3.50	100.00
1995	39.80	17.60	38.40	4.20	100.00
1994	37.80	22.30	33.70	6.60	100.00
1993	35.50	22.60	36.60	5.30	100.00
1992	39.00	17.70	35.40	7.90	100.00
1991	32.90	23.90	36.40	6.80	100.00
1990	40.40	24.70	26.30	8.60	100.00
1989	28.80	21.40	45.50	4.30	100.00
1988	24.00	21.90	49.80	4.30	100.00
1987	24.60	23.90	48.20	3.80	100.00
1986	23.20	20.90	48.60	7.30	100.00

Source: LVEMP Synthesis Report (2005)

3.2.4. Levels of mercury in water, sediments and biota in Lake Victoria basin

A review of the heavy metals in the Lake Victoria basin indicates low levels in water (Wandiga *et al.* 1983; Ochieng, 1987; Onyari and Wandiga, 1989). The sources of mercury include; gold mining operations in the lake basin as well as from biomass burning and soil erosion.

3.2.4.1. Gold mining operations in Lake Victoria basin

The impact of small-scale gold mining on water quality includes: poor sanitation, increased soil erosion, sedimentation and siltation. Mercury (Hg) contamination of surface water is related to amalgamation activities at the riverside and from dispersion of the toxic element (mercury) containing tailings. The mercury vapour released during firing of the gold-mercury amalgam escapes into the atmosphere. The vapour eventually condenses and falls onto the soil and into the water. There is potential release of mercury, its subsequent accumulation in the sediments and methylation to organo-mercury that is biomagnified in the food chain of the aquatic ecosystem (van Straaten *et al*., 2000a, b).

3.2.4.2. Biomass burning and soil erosion

Biomass burnings and soil erosion are estimated to be the major sources of Total mercury (THg) for the lake and probably constitute a larger source of THg than gold mining in Tanzania. Plants assimilate Hg from the soil and when burned, release

stored Hg to the atmosphere (Freidli *et al.* 2001). The majority of precipitation to Lake Victoria is derived from the lake catchment (Bootsma & Hecky, 1993), which frequently experiences agricultural burning. Globally, 50% of the fires seen in satellite observations are located in sub-Saharan Africa (Dwyer *et al.* 2000), indicating that biomass burnings are a highly significant potential source of THg to African lakes (Campbell, 2001). Soil erosion is another potentially important Hg source to Lake Victoria, as sequestered Hg in soil oxyhydroxide particles can be released rapidly upon reduction in water (Roulet *et al.* 1995).

Hg is a particular concern in aquatic environments and fish because Hg compounds can be microbially transformed into methylmercury (MeHg) in water and sediments (Sweet & Zelikoff, 2001). MeHg can biomagnify approximately 106-fold through the food web, resulting in high total mercury (THg) concentrations in piscivorous fish relative to water, even in areas remote from industrial sources. For the Lake Victoria situation, the general observations are that the concentrations of total mercury are usually below the WHO limit of 200 ng/g although when they approach a weight of 10 kg, THg concentrations begin to exceed that limit. A few Nile perch from Napoleon Gulf in Uganda reach the WHO limit at 3 kg (Figure 3.12). This has raised concern about the methylation rates of Hg compounds in that gulf (Campbell, 2001; Campbell *et al.* 2003).

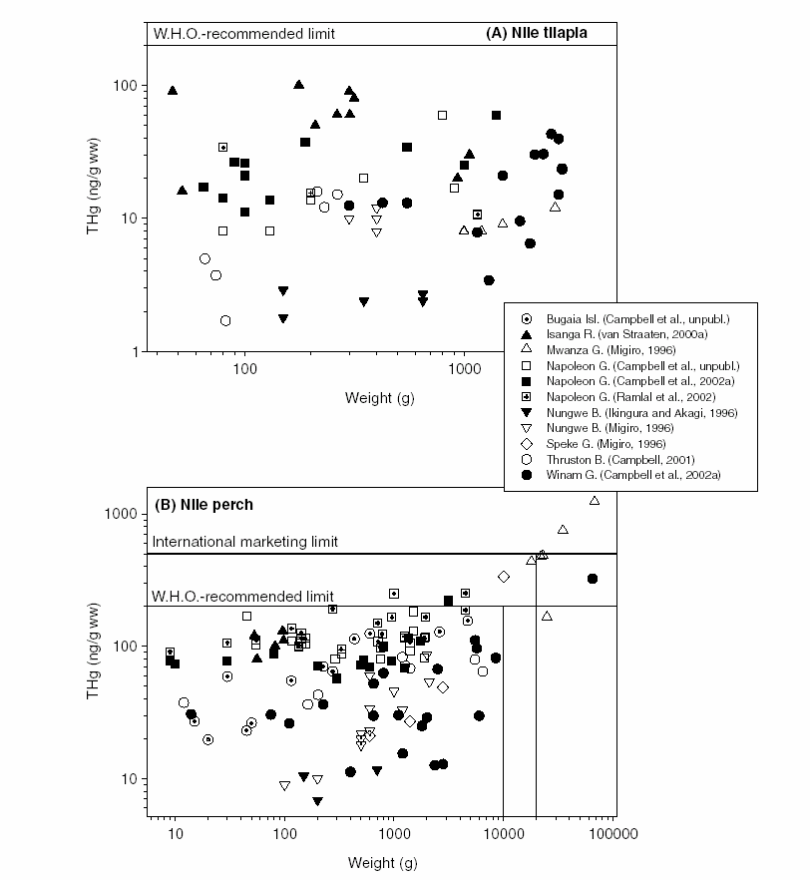


Figure 3.10 Total Mercury concentrations versus fish weight for (A) Nile tilapia and (B) Nile perch. Note the logarithmic scale. The horizontal lines indicate WHO (200 ng/g) and international (500 ng/g) marketing limits. (From Campbell *et al.* 2003)

3.2.5. Land use and sedimentation patterns in Lake Victoria basin

3.2.5.1. The current status of land use and sedimentation patterns

Cultural eutrophication arises from the activities of dense human populations in the catchment of the lake. Human land use can also lead to excessive erosion and sedimentation which affects fish habitats directly by burying food resources, reducing light penetration required for benthic photosynthesis, clogging fish gills and smothering eggs of invertebrates and fishes. Excessive sedimentation results from high sediment yields from catchments and threatens the diversity of nearshore fishes in a Lake (Cohen *et al.* 1996). Sediment yields are affected by human activities, especially agriculture, with highest global yields occurring in areas of intensive agriculture (Stone & Saunderson, 1996), especially in mountainous terrain (Milliman & Syvitski, 1992). Table 3.12 shows that cultivation is intensive in the Lake Victoria catchment.

Clearing of forests has resulted into deforestation, a dominant feature in most parts of the lake zone where land is bare following the expansion of settlements, livestock keeping, and agriculture (Hongo, 2001). Soil becomes susceptible to erosive agents when it is stripped off its protective vegetation cover; this in turn enhances the wind/water erosive force where atmospheric deposition and surface run-off are loaded with suspended sediments or dust. The problem associated with sediment transport is that they act as a carrier for nutrients (especially phosphorus), heavy metals and pesticides that adversely affect the water quality in rivers and the lake (Machiwa, 2001).

Removal of natural vegetation exposes the land surface to impact of rain and rapid saturation of the soils leading to sheet runoff and loss of suspended sediments especially from bare land just before the seasonal rains (Sundborg & Rapp, 1986). Bare soil increases wind erosion as well. These processes will increase sediment and nutrient loading into Lake Victoria. Suspended sediment concentrations and total Phosphorus are strongly correlated. The impacts of improper land use practices are shown in Figures 3.12, 3.13, 3.14.

Table 3.12 Characteristics of land use in the Lake Victoria catchment (Data from Scheren *et al*. 1996.).

	Catchment land area (1000 ha)		
	Cultivated	**Non cultivated**	**Total**
Kenya	1470.00	3400.00	4870.00
Uganda	1400.00	2100.00	3500.00
Tanzania	1500.00	5540.00	7040.00
Burundi	930.00	1130.00	2060.00
Total	5970.00	12810.00	18 780.00

The Nyando river basin has intensive land use activities, making it a major source of sediment and phosphorous flowing into Lake Victoria (Figure 3.11). Of the eleven rivers draining into Lake Victoria, the Nyando river basin has the highest average slope and average sediment transport capacity (Table 3.13). Satellite images, aerial videos, ground surveillance and sediment core analyses also indicate that there has

been massive soil movement into the lake over the last 50 years, principally from gulley erosion of the lake plain. Measurements of phosphorous (the main nutrient causing lake eutrophication - super-saturation of nutrients in the lake) in the River Sondu showed that concentrations were lower than those in the lake, but concentrations in the River Nyando were five times higher than those of River Sondu.

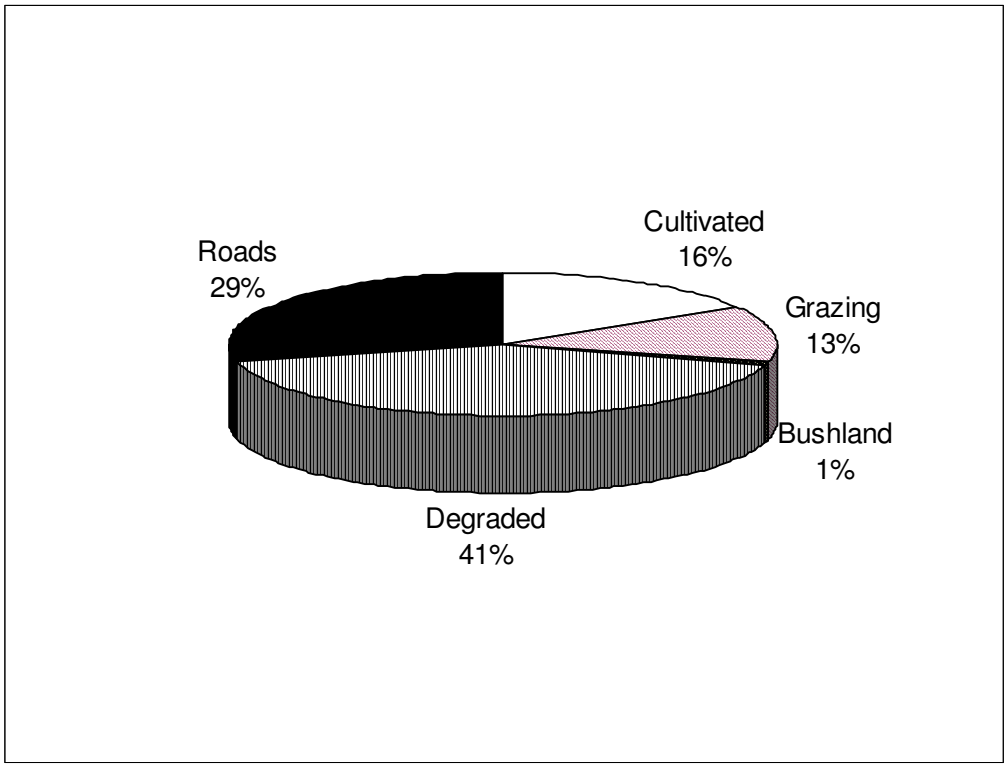
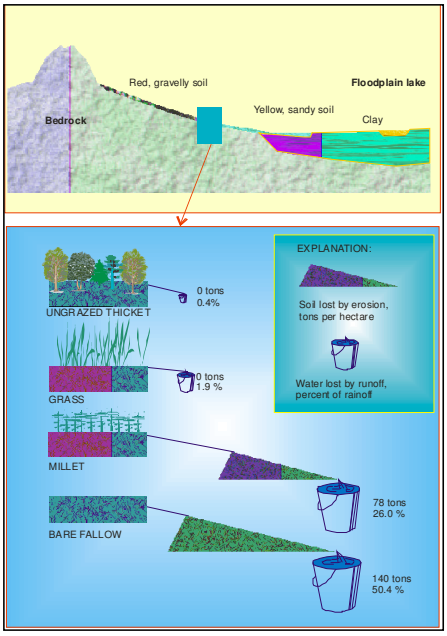


Figure 3.11 Runoff from different land use types in Bur Kamach sub-basin, Nyando basin. Data from Shepherd et al. (2000)

Table 3.13 Demographic and biophysical characterization of the inlet drainage basins of Lake Victoria (Est. – estimated; Ave. – average). Data from Shepherd *et al*. 2000

River basin	Countries sharing the basin	Est. basin size (km^2)	Ave. est. pop density (people km^2)	Ave. Annual rainfall (mm)	Ave. sediment transport capacity index	Ave. % slope
Nzoia/Yala	Kenya	15 143.00	221.00 (± 154.00)	1306.00	0.14	2.30
Nyando	**Kenya**	**3 517.00**	**174.00(± 127.00)**	**1360.00**	**0.30**	**5.00**
Sondu Miriu	Kenya	3 583.00	220.00 (± 148.00)	1 415.00	0.14	2.30
Kuja Migori	Kenya	6 612.00	224.00(± 183.00)	1 300.00	0.16	1.60
Mara	Kenya Tanzania	13 915.00	46.00(± 56.00)	1040.00	0.15	2.00
Gurumeti	Tanzania	12 290.00	21.00 (± 26.00)	874.00	0.12	1.60
Mbalageti	Tanzania	5 702.00	37.00 (± 22.00)	766.00	0.05	0.60
Duma/Simiyu	Tanzania	9 702.00	50.00 (± 26.00)	804.00	0.06	0.50
Magoga/Mueme	Tanzania	5 104.00	88.00 (± 47.00)	842.00	0.05	0.40
Isonga	Tanzania	8 972.00	48.00 (± 22.00)	897.00	0.04	0.30
Kagera	Tanzania Uganda Rwanda Burundi	59 178.00	18.10 (± 196.00)	1 051.00	0.24	3.00
Lake Edge	Kenya Uganda Tanzania	40 682.00	133.00 (± 175.00)	1 077.00	0.21	1.90



Ecosystem	Soil loss (Tonnes/ha)	Water loss (%)
Ungrazed land	0	0.4
Grass	0	1.9
Millet	78	26
Bare fallow	140	50.4

Figure 3.12 Soil erosion patterns in different ecosystems. Removal of natural vegetation exposes the land surface to impact of rain and rapid saturation of the soils leading to sheet runoff and loss of suspended sediments especially from bare land just before the seasonal rains begin as illustrated above. Bare soil increases wind erosion as well. These processes will increase sediment and nutrient loading into Lake Victoria.

3.2.5.2. Ongoing efforts to control land and water degradation in Lake Victoria basin

There are four objectives of Transvic project are:

a) Identify and evaluate land management “hot spots” in the Lake Victoria basin and identify intervention points for preventing or mitigating those hot spots.
b) Identify and evaluate technologies, institutional arrangements and policies for alleviating poverty while protecting the local and regional environmental of the Lake Victoria basin.

c) Quantify the actual and potential impacts of promising land management interventions on human welfare (food security, income, gender and equality) and the environment (soil quality, water quality and hydrologic function).

d) Enhance research and extension linkages for improved land management in the Lake Victoria basin.

The TransVic project has produced several important outputs for improving livelihoods and landscapes in the Lake Victoria basin

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i) Sedimentation rates at the mouth of the river Nyando have increased by 3-4 times over the last 100 years and have punctuated by "big events" coinciding with major rainfall events.

ii) Approximately 60% of the 3500 km2 Nyando basin are sediment source areas that have been severely depleted of major soil nutrients.

iii) Water quality in the Nyando, Yala and Nzoia rivers is extremely low, with exceptionally high levels of turbidity during the high rainfall year of 2001.

iv) There is some evidence that flooding problems are becoming more frequent and severe –likely due to deforestation in the headwaters and the buildup of sediments in the lower parts of the Nyando basin. The Government should reconsider the recommendations of the Nyando Action Plan first developed in the early 1980s.

v) Community trials in 10 focal areas suggest that the most promising solutions to the land degradation problems in the Nyando basin are: a) water management – especially spring protection; b) tea and bananas where appropriate; and c) agroforestry species that produce foliage that is not attractive for livestock (*Crotalaria grahamia, Cajanus Cajan* and *Tephrosia candida*).

Figure 3.13 Land use activities destroying the environment (Adapted from Swallow *et al*. 2002).

Figure 3.14 Gulley erosion in Katuk Kodero within the Lake Victoria basin resulting from poor land use (Adapted from Swallow *et al*. 2002)

3.2.6. Solid waste management

3.2.6.1. The status of solid wastes

Solid waste is the unwanted material that can become a big nuisance. It consists of domestic garbage and other discarded material waste that are swept up from the streets and unwanted items and materials of various types from commercial and industrial enterprises. These items are also referred to as refuse.

Solid waste can cause serious and long term pollution of land, air and water. The housing near the disposal sites are threatened by explosive gases generated by decomposing waste (Lwenya, 2002; Kibwage, 1996). Water resources can be contaminated by the leachates while the air is polluted from the smoke from burning refuse. Even modern refuse incinerators produce toxic gases when plastics are burned. Refuse also affects the health of the community due to flies, mosquitoes, rats and cockroaches. Piles of refuse encourage more indiscriminate damping of refuse. According to Lwenya (2002), more waste is generated in high residential areas but improper disposal of waste is more enormous in the low-income areas. The main stakeholders in this enterprise are;

a) Municipalities
b) Composting groups
c) Other stakeholders engaged in solid waste management, which includes collecting and disposal.

Research indicates that the systematic waste reuse and recycling is the best way to reduce waste. The metals within the waste can be reprocessed and plastics can be recycled. The organic waste from the soil should be returned to the soil and the gases they produce can be harnessed as energy. The reused recycled or recovered organic waste can be composted at the farm level to produce organic fertilizer. There is need for an efficient, operational participatory efficient system for solid waste management.

3.2.6.2. Solid waste management systems

The current wastewater management systems emphasize on use, recycling and reuse. Part of the solid waste generated is processed by large and small recycling enterprises. The informal sector is involved widely with individual groups of waste pickers, dealers and wholesale dealers participating in solid as well as raw materials to recycle or reuse. The recycling of organic waste through composting and producing manure is a form of waste reduction or minimization. The process also enhances agricultural production and is environmentally friendly. The main categories of organic waste include; poultry waste, livestock waste, vegetable and food waste while others are used in the horticultural farms, crop production, as animal feeds and Napier grass production. The farmers who use this organic fertlizers include; mixed farmers, commercial farmers, subsistence and flowerpot and small gardens that use this organic manure to fertilize their crops.

Polythene and plastic materials which are non biodegradable are remelted and recycled to make plastic poles, art and craft such as baskets. Emphasis is to replace the non biodegradable material to biodegradable ones.

3.2.7 Air pollution

Air pollution is an increasingly important environmental problem in Africa. Air pollution is a chemical, physical, or biological agent that modifies the natural characteristics of the atmosphere. Worldwide air pollution is responsible for large numbers of deaths and cases of respiratory disease. Air pollution in urban centres could be linked to human health impacts. Household and industrial energy consumption is predicted to increase tremendously, with consequent significant growth in sulphur and nitrogen emissions. Emitted pollutant gases have the capacity to be transported over large distances, and may give rise to depositions in and around the basin. Some of the major industrial and urban centres within the basin are located in border areas and the dominant weather patterns may facilitate transboundary transport of air pollutants. Pollutants can thus be carried long distances in the region and even across the borders, making air pollution a major transboundary issue.

In the Lake Victoria basin, the most important source of air pollution are motor vehicles, sea going vessels, factories (Sugar, brewery, paper, chemical, plastics and fish factories), incinerators, municipal garbage dumps, artisanal fish processing, household energy sources etc. There are also cases of wild fires particularly from wetlands that release nutrients into the atmosphere amounting to a major atmospheric pollution source. Emissions of sulphur dioxide have been rising steadily as industrialization occurs. In the lake basin, paper industries are the most significant sources of sulphur dioxide and nitrogen dioxide. Impacts of acid rain have already been reported on forests, crops and surface waters close to paper factories, for example around Webuye Panpaper mill, iron sheet corrosion is also common. Air pollution within the Lake Victoria Basin in Kenya is though not considered to be a high risk as yet. There are many available air pollution control technologies and urban planning strategies available to reduce air pollution; however, costs of addressing the issue are high.

3.3. Biogeographical distribution

Biogeography defines the distribution of biota across geographical boundaries. For this TDA the information on biogeographical distribution has been sourced extensively from Kansoma (*In press)*.

Biological diversity, or biodiversity, means the variety of life on earth and includes the entire web of living organisms as outlined in the Convention on Biological Diversity (1992). The objective of the Convention on Biological Diversity is "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits." Sustainable use is defined in the Convention as "the use of components of biodiversity in a way and at a rate that does not lead to long-term decline" but maintains the "potential to meet the needs and aspirations of present and future generations." The continued existence of humanity on the planet and the elimination of global poverty depend on recognizing the natural environment, or biodiversity, as the foundation of a sound economy. It is only possible to enjoy economic prosperity now and in the future if a healthy environment is maintained.

Biodiversity features of Lake Victoria are depicted in Table 3.14. Lake Victoria used to support over 350 species of cichlids as well as at least 51 other non-cichlid species such as endemic species of catfishes, electric fishes (mormyrids), carps, crustaceans, mollusks and insects (Ogari, 1985; Ogari & Dadzie, 1988). Nearly all of the cichlids (99%) are endemic haplochromines (Witte *et al.* 1992a). Most of the actual fish species from lake also lived in the preceding west-flowing rivers, but the cichlids in particular, had a remarkable burst of speciation in response to the change from river to lake conditions.

Table 3.14 The trophic groups in the Lake Victoria and their estimated species diversities

Trophic group	Known	Described	Recommended for listing
Detritivore/phytoplanktivores	13+	3	Endangered
Phytoplanktivores	3	0	Endangered

Epilithic algae grazers	3+	1	Probably secure
Epiphytic algae grazers	7+	3	Probably secure
Plant eaters	2	2	Status undetermined
Pharyngeal mollusc crushers	9+	6	Threatened
Zooplanktivore	21+	8	Threatened
Insectivore	29+	18	Endangered in part
Prawn eaters	13+	11	Endangered
Crab eaters	1	0	Probably secure
Pisicivore *sensu stricto*	109+	41	Endangered
Paedophages	24+	8	Endangered
Scale eaters	2	2	Endangered
Parasite eaters	53	6	Endangered
Unknown	53	6	
Total	**302**	**119**	

Similar things happened in other great lakes, but in Lake Victoria it happened much more recently, more rapidly and with fewer opportunities for ecological isolation in different types of habitat. Speciation apparently occurred less than 225,000 years ago with a major burst occurring 12,000 years ago. The cichlids are capable of rapid genetic change and are more prone to speciation than other groups of African fish. From the primitive insect-eating types, mouths and pharynxes have evolved to allow feeding on plants, mollusks, fish, and even the eggs and young larvae carried in mouth of brooding females of most cichlid species.

From 1954 (year of introduction of the Nile Perch) till 1980s this exotic predator managed to coexist with the haplochromines leading to local population explosions of Nile perch. As a consequence, around 350 haplochromine species declined and at least 50% of the cichlid species have become extinct or endangered. In terms of loss of fish species, the worst affected region is the East African region (Table 3.15). The once abundant plankton eating fish have been decimated by introduced species as well as the changes in water quality (Verschuren *et al.* 2002; Kaufman, 1992). The cichlids (small fish) prefer clear water, whereas the Nile perch, which prey on them, are adapted to live in murky water. The endemic fishes are thus doubly disadvantaged, with the net effect that more nutrients now remain in the water column.

Table 3.15 List of African countries with large number of threatened fish species (IUCN: red list of threatened animals, 1996).

Country	Threatened fish species
Uganda	28
South Africa	27
Cameroon	26
Kenya	20
Tanzania	19
Madagascar	13
Seychelles	0

3.3.1. Phytoplankton
3.3.1.1. Phytoplankton resources

Phytoplankton (algae) is the most important primary producer in Lake Victoria and a vital basis for higher production, including that of fish. Recent studies indicate a dominance of blue green algae (Cyanophyceae) over diatoms (Bacillariophyceae) and green algae (Chlorophyceae) the least dominant.

3.3.1.1. Changes in the algal composition

The modification of the water chemistry and physical environment of Lake Victoria has been invoked to explain succession of algal species composition (Akiyama *et al*. 1977, Hecky 1993, Hecky *et al*. 1996, Lehman *et al*. 1998, Lung'ayia *et al*. 2000; Kling *et al*. 2001; Mugidde 2001). Recent reports show that the historic diatom community of *Aulacoseira* (*Melosira*) and *Cyclostephanos* that made up 70%-99% of the diatom biomass during periods of more stable thermal stratification (March-April) and deep complete mixing (July) in 1960s (Talling 1957a 1957b, Evans 1962a 1962b) has been replaced by *Nitzschia* spp. that now dominate the diatom community (Kling *et al*. 2001).

Despite a 7-fold reduction in soluble reactive silica in the water column, diatoms have increased their biomass since the 1960s in Lake Victoria (Kling *et al*. 2001). A wide variety of cyanobacteria (blue-green algae) that were consistently low in the 1960s now appear more frequently and filamentous heterocystous cyanobacteria such as *Cylindrospermopsis* make up a large fraction of the algal community of the lake (Figure 3.15). Green algae now occur in very low abundance and several taxa, in particular desmids that were present in 1950s-1960s have declined or disappeared. The large chlorophytes such as *Pediastrum* spp. are rare.

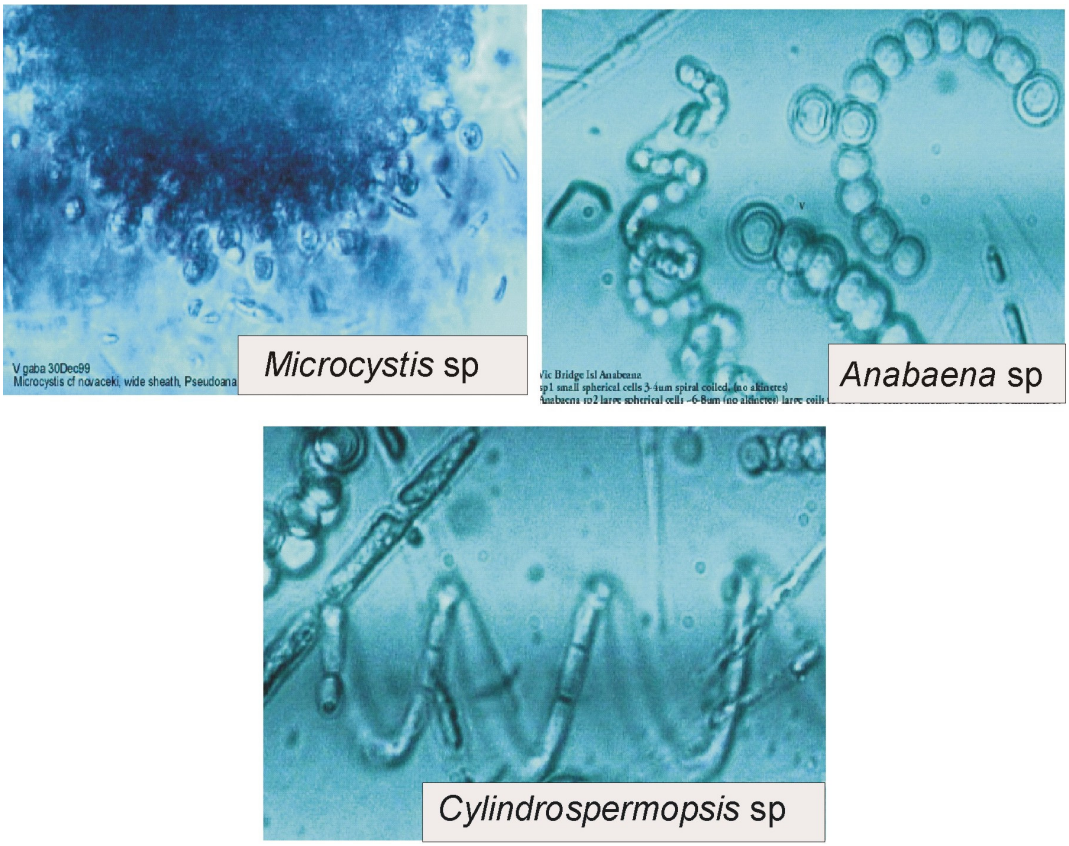


Figure 3.15 The current dominant algae species in Lake Victoria

3.3.1.2. Effects of the changes in the algal composition and biomass

Excessive growth of phytoplankton (water blooms) in freshwaters may cause large-scale death of a number of aquatic animals by changing the chemistry of water (through oxygen depletion at night) or production of toxins. Reports on massive fish kill in Lake Victoria exist. For example in the early 1990's massive fish kills were observed in the Nyanza Gulf in Kenya and this was attributed to effects of cyanobacteria blooms (Ochumba 1990).

Several cyanophyte species are known to form toxins (Table 3.16). The toxins are classified according to the target of their toxic action as hepatotoxins, neurotoxins and dematotoxins. Hepatotoxins have been characterised from species of *Microcystis*, *Oscillatoria*, *Anabaena, Nostoc* and *Nodularia*. Neurotoxins are produced by benthic *Oscillatoria* and dematotoxin by *Lyngbya* (Sivonen 1996). Some of these species of cyanobacteria occur in the Lake Victoria basin and in high abundances e.g. *Microcystis* (Table 3.17). There is therefore a high risk of development of bloom of toxin producing algae. However, the toxicity of various species is strain specific and not species specific. Moreover, toxin production occurs only under certain favourable conditions.

Table 3.16 Levels of cyanotoxins in selected bays of Lake Victoria during the March 2005 sampling period (Data from the IFMP project reports, 2005)

Locality	Conc. in (µg/mg) dry weight
Murchison bay	0.03
Napoleon Gulf	0.20
Mwanza Gulf	0.99

Table 3.17 Levels of microcystin from Gaba water works (Uganda)*

Date	Gl intake	G2 intake	G3	G4	G5	G6	Shoreline
Units (µg/l)							
July 31	<0.5	< 0.5	nd	<0.5	< 0.5	nd	
Aug – 07	0.5	0.5	nd	< 0.5		< 0.5	
Aug – 14	< 0.5	< 0.5	nd	< 0.5	< 0.5	nd	0.5 – 3.0
Aug. – 21	nd	nd	nd	nd	nd	nd	
Octo- 02	nd	0.5	0.5	0.5-3.0	0.5-3.0	nd	
Octo- 16	< 0.5	0.5	0.5-3.0	0.5-3.0	0.5- 3.0	nd	
Nov-05	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	
Nov -20	0.5-3.0	0.5-3.0	0.5-3.0	0.5-3.0	0.5-3.0	0.5	> 3.0

* WHO standards for acceptable level in drinking water is 1 µg/l (Data from the IFMP reports 2005)

3.3.2. Zooplankton resources

Zooplankton communities in the Victoria basin lakes are made up of mostly crustaceans in which the key groups are copepods and cladocerans or water fleas. Non-crustacean zooplankton include rotifers and insect larvae largely chaoborids (Figure 3.16; Table 3.18). The latter are semi-planktonic, living in or near bottom sediments during daytime but ascending into the water column by night. The freshwater prawn, *Caridina nilotica* Roux is commonly encountered in the plankton of Lake Victoria especially in samples taken at night owing to diurnal migratory behaviour similar to that of chaoborid larvae. Occasionally water mites (*Hydracarina*) also occur in the pelagial zone. In Lake Victoria, zooplankton is an important food source for fish larvae. It is therefore believed that the survival of fish larvae and eventual recruitment of various fish species into the fishery largely depends on zooplankton availability. The juveniles of Nile perch feed largely on the semi-planktonic freshwater prawn, *Caridina nilotica* (Ogutu-Ohwayo 1990; Ogari & Dadzie 1988).

The piscivorous adult Nile perch can be considered to remain indirectly dependent on zooplankton through feeding on zooplanktivorous *Rastrineobola argentea* Pellegrin (*mukene, omena or dagaa*). Zooplanktons form the sole food source for the pelagic cyprinid, *Rastrineobola argentea* (Mwebaza-Ndawula 1998) and pelagic haplochromines. In the recent past changes have occurred among invertebrates. The composition and diversity of zooplankton communities changed from dominance of larger types (calanoid copepods; cladocerans) to smaller types (cyclopoid copepods). This simplified the food web and reduced the grazing efficiency of the

zooplankton. Earlier studies indicated a predominance of Calanoid (50.1%) offshore. Recent studies (Mwebaza-Ndawula, 1994) showed a predominance of cyclopoids. Increase in the algal biomass has also recently favoured the proliferation of fresh water shrimp *Caridina nilotica.*

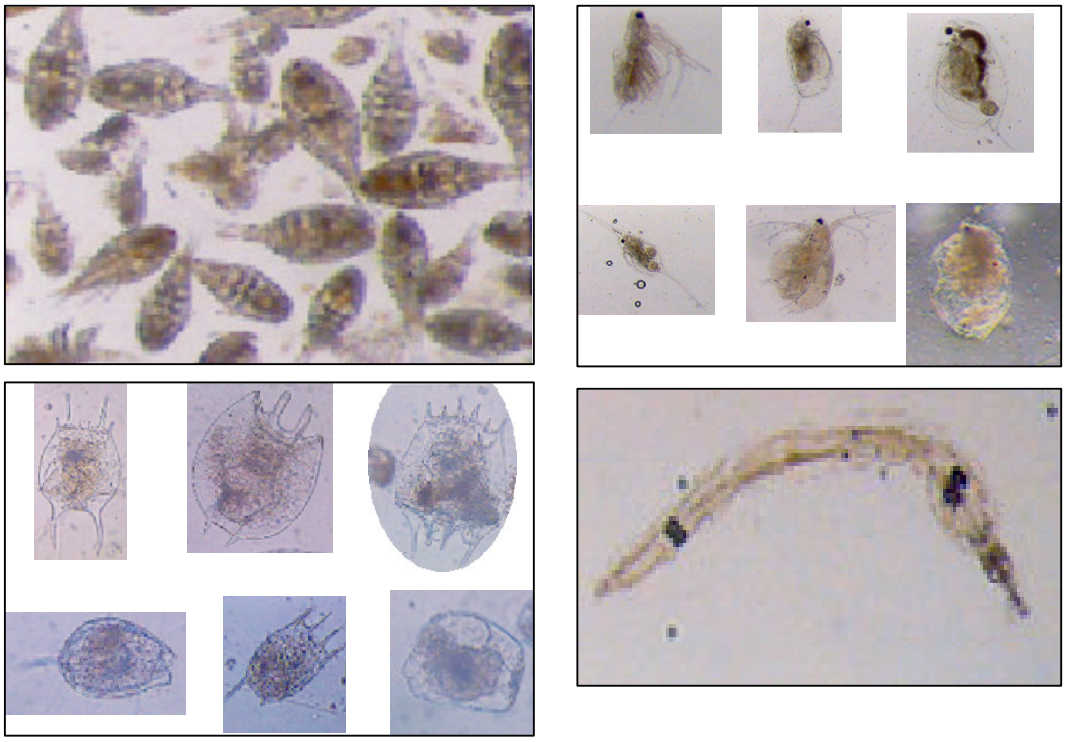


Figure 3.16 Pictures of Copepoda, Cladocera and Rotifera. Top from left to right; Copepoda, Cladocera (water fleas). Bottom from left to right; Rotifera. Chaoborid larva (Adapted from P. Kansoma (eds))

Table 3.18 A Checklist of zooplankton species identified in Lake Victoria. (P- present, A- absent] (Adapted from P. Kansoma (eds.).

Taxa	Kenya	Tanzania	Uganda
Crustaceans: Cyclopoida			
Thermocyclops neglectus	P	P	P
T.emini	P	P	P
T. incisus	P	P	P
T. oblongatus	P	A	P
T. decipiens	P	A	A
Mesocyclops spp.	P	P	P
Tropocyclops confinnis	P	P	P
T. tenellus	P	P	P
Calanoida			
Thermodiaptomus galeboides	P	P	P
Tropodiaptomus stuhlmanni	P	P	P
Cladocera			
Daphnia lumholtzi (hemeted)	P	P	P
D. lumholtzi var*. monacha*	P	P	P
D. longispina	P	P	P
D. barbata	P	A	A
Ceriodaphnia cornuta	P	P	P
Diaphanosoma excisum	P	P	P
Bosmina longirostris	P	P	P
Chydorus sphaericum	P	A	P
Alona sp.	P	A	P
Moina micrura	P	P	P
Decapoda			
Caridina nilotica	P	P	P
Non-crustaceans: Rotifera			
Brachionus angularis	P	P	P
B. calyciflorus	P	P	P
B. caudatus	P	P	P
B. patulus	A	A	P
B. falcatus	P	P	P
Filinia longiseta	P	P	P
F. opliensis	P	P	P
Keratella cochlearis	P	P	P
K.quadrata	P	P	P
K. tropica	P	P	P
Polyarthra vulgaris	P	P	P
Sychaeta sp.	P	P	P
Lecane spp.	P	P	P
Monostyla sp.	P	A	P
Collotheca sp.	P	A	P
Asplanchna brightwelli	P	P	P
Ascomorpha sp.	P	P	P
Trichocerca cylindrical	P	P	P
Aneuropsis sp.	P	A	P
Epiphanes	P	A	P
Euclanis sp.	P	P	P
Hexathra mira	P	A	P
Platyias patulus	P	A	A
Pompholyx sp.	P	A	P
Insecta			
Chaoborus larvae/pupae	P	P	P
Arachnida			
Acarid mites	A	A	P

3.3.3. Zoobenthos resources

The benthic fauna of Lake Victoria is composed mainly of mollusks (ca. 44%) and insect larvae and nymphs (ca. 41%). Oligochaetes, leeches, crustaceans, nematodes and ostracods are also present but do not make up a major part of the benthic species composition (Figures 3.17, 3.18, 3.19).

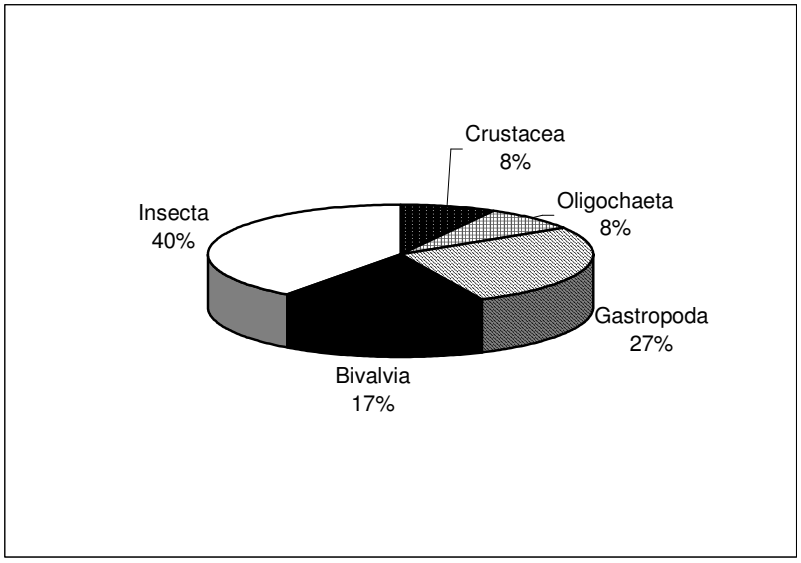


Figure 3.17 Taxonomic composition of major benthic macroinvertebrates groups in Lake Victoria**.** (Adapted from P. Kansoma (eds).

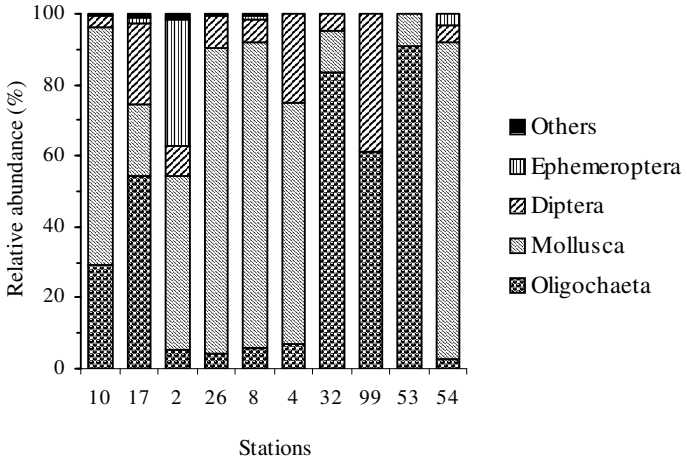


Figure 3.18 Relative abundance (% mean density individuals m-2) of the major macroinvertebrates taxonomic groups in the various stations in Kenya waters of Lake Victoria (March-1993-March 1994). [Adapted P. Kansoma (eds)].

Figure 3.19 Examples of common aquatic macro-invertebrates. Top row left to right: snails, clam, leech, seed shrimp Bottom row: juvenile may fly, water bug, damsel fly. [Adapted from P. Kansoma (eds)]

3.4 Fisheries Sector

3.4.1 Background on the fisheries sector in Kenya

Kenya's fisheries sub-sector is based on three main fish resource bases, namely; inland fresh-water, coastal marine and aquaculture. Of these, inland fresh-water fisheries are the most important, with Lake Victoria dominating fish production. The lake alone contributed 92% (equivalent to 142,000 tonnes) of an annual mean of 155,000 tonnes of fish landed in Kenya between 1998 and 2005. Besides Lake Victoria, the other fresh-water fish sources are lakes Turkana, Baringo, Naivasha, and Jipe and several dams and rivers spread across the country, which collectively produce 3% of total fish. Marine and aquaculture fisheries constitute only about 4% and 1% respectively of fish landed in the country. Only three species – Nile perch (*Lates niloticus*), *dagaa* (*Rastrineobola argentea*) and tilapia (*Oreochromis species*) - constituted about 52%, 33% and 10% respectively of the total fish caught in Lake Victoria, with all the other species contributing just about 5% (Fig. 3.20). The endemic fish species had been overtaken by exotic species in the fish production (Fig. 3.22).

Before the introduction of Nile Perch and the exotic cichlids in the 1950's, Lake Victoria consisted of an artisanal multi-species fishery (Welcomme 1988). Apart from the tilapiines, *Oreochromis esculentus* (Graham) and *Oreochromis variabilis* that were most important commercially, other species also formed a significant fishery (Marten 1979). These included lungfish *Protopterus aethiopicus* (Herkell), the catfish (*Clarias gariepinus*) (Burchell), *Bagrus docmak* (Forskal) and and the cyprinid, *Labeo victorianus*. *Haplochromines* were the most abundant group of fishes in Lake Victoria and formed about 80% of the fish biomass during the 1970s (Kudhongania & Cordone 1974). There were over 300 haplochromine species, more than 99% of them endemic to the lake (van Oijen *et al.* 1981; Witte *et al.* 1992).

They occupied all trophic levels and played an important role in the flow of organic matter in the ecosystem. Up to 11 trophic groups of haplochromine cichlids were identified from Mwanza Gulf alone (Witte & van Oijen 1990).

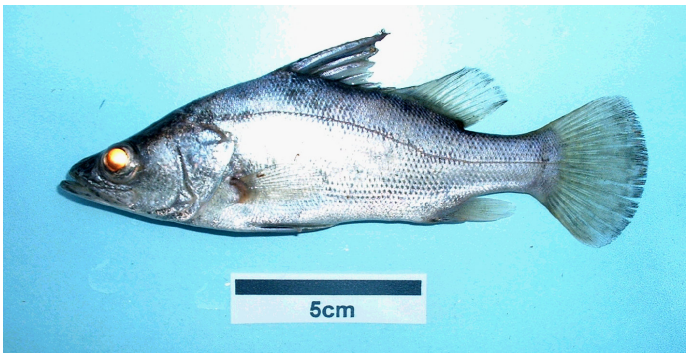
The Lake Victoria fish stocks and the fisheries have undergone remarkable changes over the past 20 years. Signs of overfishing were reported as early as 1970 when catch rates of tilapia dropped from 50 – 100 fish per 50 m long net with 127 mm stretched mesh to less than five fish (Ssentongo 1972). As the stocks of Nile perch increased, fish species diversity, especially of the haplochromines, decreased rapidly. The contribution of haplochromines to fish biomass in the lake decreased from 80% in the 1970s to less than 1% in the 1980s (Kudhongania & Cordone 1974; Okaronon *et al.* 1985). Many important food fish species seemed to have disappeared, and later even *L. niloticus,* showed signs of decline (Othina & Osewe–Odera 1996).

From those changes in the fishery resources a number of management measures took effect including a ban on beach seine nets and under-sized mesh nets (<127 mm stretched mesh) in 1994, and a ban on trawlers in 1996. From the conservation point of view, the decline and virtual extinction of the Lake Victoria cichlid species must be considered as an irreplaceable loss. It is anticipated that a number of reasons are behind the decline in the fish species diversity. For example, haplochromines declined or were eliminated in some areas largely due to predation, over fishing and environmental changes (Acere 1988; Ogutu-Ohwayo 1988). The indigenous tilapiines (*O. esculentus* and *O. variabilis)* were eliminated as a result of inter-specific species competition with introduced exotic species, mainly *O. niloticus, Tilapia zillii, T. rendallii* and *O. leucostictus* (Balirwa 1990). The decomposition of algae and water hyacinth has resulted into depletion of dissolved oxygen, thus making much of water column uninhabitable by cichlid and other aquatic life. Eutrophication has also disturbed traditional mating systems, which has lead to the decline of cichlid species (Goudswaard & Witte 1985).

3.4.2 Catch trends of commercial species

Detailed analysis of the catch trend of commercial species reveals four marked fish catch regimes since 1976 (Fig. 3.21). The first period extended from 1976 up to 1985, when less than 90,000 tonnes were landed each year. From 1986 to 1988 the annual catches ranged between 102,000 tonnes and 138,000 tonnes. The period 1989 to 1993 had record catches, largely attributed to the Nile perch boom. During this period annual catches ranged between 211,000 tonnes and 219,000 tonnes. There was a decline in catches from 1994 to 1998, the period of the Nile perch bans. The catches ranged from 151,000 tonnes to 193,000 tonnes per year within this time. The period after 2000 has experienced very low catches which are comparable to catches in 1986 to 1988 period.

Catch data collected after 2004 now indicate resurgence in *dagaa* composition of total catch in relation to Nile perch composition. The most recent catch estimates indicate that a total of about 160,000 tonnes of fish were landed from Lake Victoria (Kenyan part) in 2005, valued at about US$ 88 million. Of this, Nile perch constituted 51,000 tonnes, Tilapia 22,000 tonnes, Dagaa 82,000 tonnes and other species a combined 5 tonnes. Despite Nile perch composing only 32% of catch



Nile Perch (52%)

Tilapia (10%)

Dagaa (33%)

volumes, its landed value was estimated at $57 million, representing 65% of total value. The value of tilapia and dagaa were each estimated at $15 million.

Figure 3.20 Commercial species of Lake Victoria

3.4.2 Export markets for Lake Victoria fish

Starting from early 1980s, Nile perch exports increased steadily till the mid 1990s. This trend was interrupted by successive export bans in 1997, 1998 and 1999 of fish and fishery products from Lake Victoria to EU, which was then importing about 87% of all fish exports from Kenya (Abila, 2003). The lowest proportional intake by the EU was in 1999 when it imported only 6% of Kenya's fish. However, it should be noted that the EU has consistently offered the highest prices for Kenya's fish, hence, despite the emergence of new markets the overall value of exports went down during the bans (Figure 3.23). In 2002-2003, Kenya exported about 17,000 tonnes of Nile perch per year to at least 26 countries in nearly all continents (Abila and Werimo, 2005). However, Kenya currently has the lowest volumes of Nile perch exports from among the three countries (Tables 3.19 and 3.20).

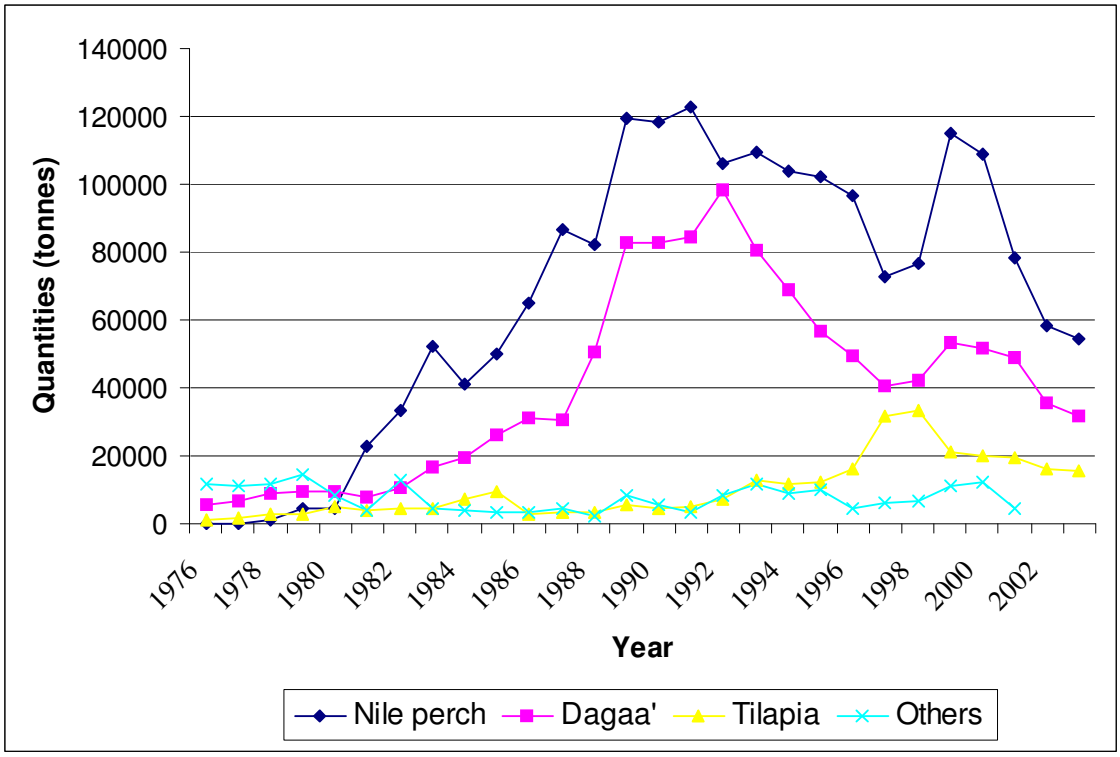


Figure 3.21 Catch trend of major commercial species (1976-2004)
Sources: Fisheries Department statistics and KMFRI

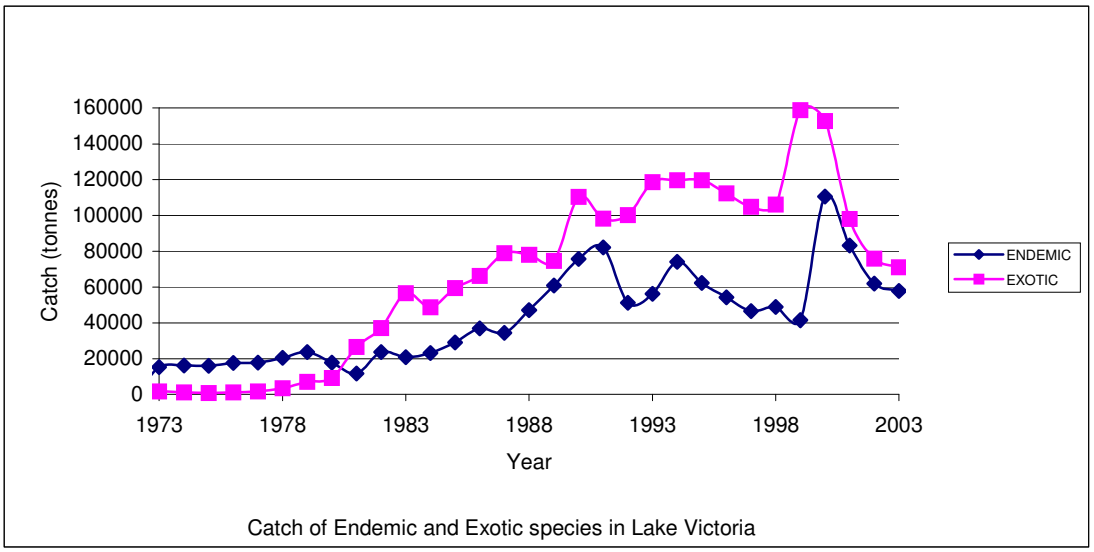


Figure 3.22 Comparative catches between exotic and endemic species in Lake Victoria (1973-2003)

Table 3.19 Nile perch exports grouped by market regions (Tonnes)

Year	***Market destination***			
	EU	**Far East**	**Israel**	**Others**
1996	10,388	1,801	3,431	1,120
1997	6,882	2,664	4,244	929
1998	2,320	2,201	5,252	1,349
1999	742	2,722	5,529	2,894
2000	1,680	4,146	7,185	2,468
2001	3,818	4,650	7,530	1,947
2002	5,783	4,647	4,799	1,878
2003	6,081	3,888	5,341	1,135

Source: Kenya Fish Processors and Exporters Association and Fisheries Department

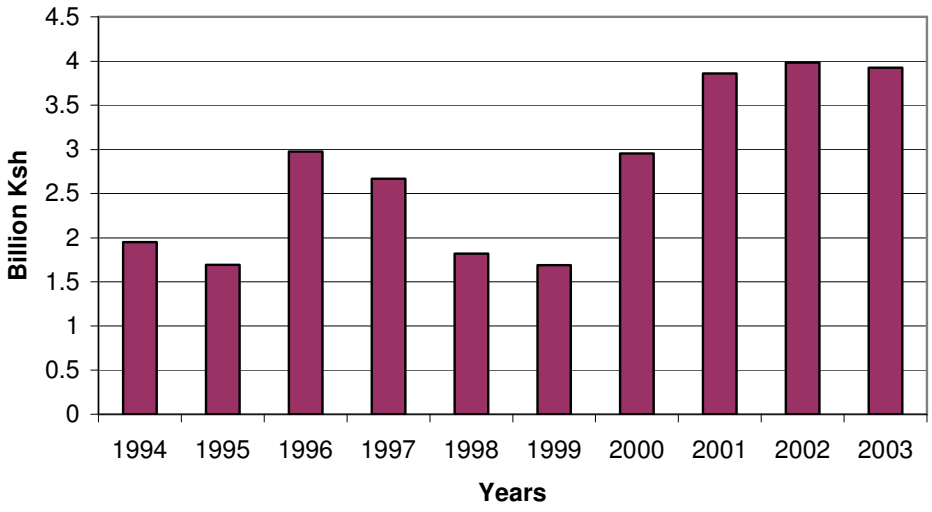


Figure 3.23 Value of Nile perch exports (1994-2003)
Source: Kenya Fisheries Department/AFIPEK/ KMFRI

Table 3.20 Comparative Nile perch exports from Kenya, Tanzania, Uganda

	Volumes (MT '000)			**Value ($ '000)**		
Year	**Kenya**	**Tanzania**	**Uganda**	**Kenya**	**Tanzania**	**Uganda**
1991	10,198		4,751	11,395		5,309
1992	10,971	4,248	4,831	14,649	5,672	6,451
1993	14,531	6,097	6,037	21,198	6,449	8,807

1994	11,967	8,454	6,563	26,930	8,942	14,769
1995	10,983	12,405	12,971	21,933	13,122	25,903
1996	16,477	20,296	16,396	39,976	52,278	39,781
1997	14,719	23,076	9,839	43,084	54,821	28,800
1998	11,698	36,386	11,604	29,974	65,728	29,733
1999	12,482	23,757	13,342	34,249	51,993	36,608
2000	15,826	32,601	15,876	34,254	49,796	34,363
2001	17,947	32,423	28,153	50,385	79,536	79,039
2002	16,456	24,732	25,169	52,248	82,516	87,574
2003	16,546	32,436	25,111	50,908	104,458	86,343
2004	15,728	34,707	30,057	52,084	87,503	102,917

Source: LVFO

3.4.3 Riverine fisheries

A large variety of riverine fish species have been identified in Kenya's rivers, particularly those entering Lake Victoria (Table 3.21**)**. Riverine species have supported localised fish markets in addition to their contribution to biodiversity. The river systems are quite vulnerable to over-exploitation and the adverse effects of environmental degradation. Fish catches in the rivers have been reducing since the 1940s. Studies conducted reveal that the total annual output from some of the rivers (e.g. Sondu-Miriu), have declined by up to 90%, as compared to the catch levels in the 1950s and 1960s.

The main causes of the decline in the catches of riverine species include overfishing by destructive fishing methods, papyrus encroachment, habitat destruction, predation by Nile perch, poor management and pollution. Kenyan river fisheries are prone to the effects of pollution, irrigation and hydropower development (for example, on rivers Kuja and Sondu-Miriu).

Table 3.21 Common riverine fish species in the Lake Victoria basin
(- Not known)

Scientific name	**Luo names**	**Common English name**
Alestes nurse	-	-
*Aplocheilichthys bukobanus***	-	-
Bagrus dogmac	*Seu*	-
Barbus altianalis	*Fuani*	-
Barbus cercops	*Adel*	-
Barbus neglectus	*Adel*	-
Barbus nyanzae	*Adel*	-
Barbus yongei	*Adel*	-
Brycinus jacksonii	*Osoga*	-
Brycinus sadleri	*Ndera*	-
Clarias gariepinus	*Mumi*	Cat fish
Clarias mossambicus	*Mumi*	Cat fish
Ctenopoma muriei	*Oyusi*	-
Gnathonemus longiberbis	*Ondhore*	-
Haplochromis spp.	*Fulu*	-
Labeo victorianus	*Ningu*	-

Lates niloticus	*Mbuta*	Nile perch
Marcusenius grahami	*Ondhore*	-
Mastacembalus frenatus	*Okunga*	-
Micropterus salmoides	*Chengu*	-
Mormyrus Kannume	*Suma*	-
Oreochromis leucosticus	*Opat*	-
Oreochromis niloticus	*Nyamami*	Tilapia
Oreochromis variabilis	*Mbiru*	Tilapia
Petrecephalus cutostoma	*Obu*	-
Protopterus aethiopicus	*Kamongo*	Mud fish
*Schilbe intermedius**	*Sire*	-
*Schilbe mystus**	*Sire*	-
Synodontis afrofischeri	*Okoko rateng*	-
Synodontis victoriae	*Okoko rachar*	-
Tilapia zilli	*Silli*	-
Xenoclarias spp.	*Ndhira*	-

3.4.4 Aquaculture production

Aquaculture contributes just about 1% of the total fish landed in Kenya, and its growth has largely stagnated over the last decades (Figure 3.24). Aquaculture has huge potential for expansion. Considering that Lake Victoria has shown signs of over-exploitation, it would be justified to invest resources towards expanding and modernising aquaculture production systems. The main fish species presently produced in aquaculture in Kenya are *Oreochromis niloticus, Tilapia zillii, Clarias gariepinus* and *Cyprinus carpio.*

At present aquaculture in Kenya is subsistence, adopting low investment and, in return, getting low pond production. Fish-farming system in Kenya is underdeveloped. It is practiced at low levels of intensification using the following holding units;

i) Pond culture: These mainly use earthen ponds for extensive or semi-intensive aquaculture. Most of Tilapines, catfish and common carp are cultured in such ponds
ii) Raceway culture: These are rectangular ponds through which water flow continuously. They are either concrete or earthen, although the latter are more common in Kenya. This unit allows for high stocking densities because of the high water exchange rate and provision of a complete diet for the fish. Raceway culture is used in most trout farms.
iii) Tank culture: Tanks are usually circular concrete structures with a central outlet. This system deploys continuous water flow and complete feeding with formulated feeds.

Aquaculture production in Western Province is comparatively developed, followed by Central and Nyanza provinces. These regional differences are largely attributable to physical suitability of soils and land topography, availability of sufficient water supply, attitudes of residents towards fish farming, a tradition of fishing or fish farming and availability of extension and other support services.

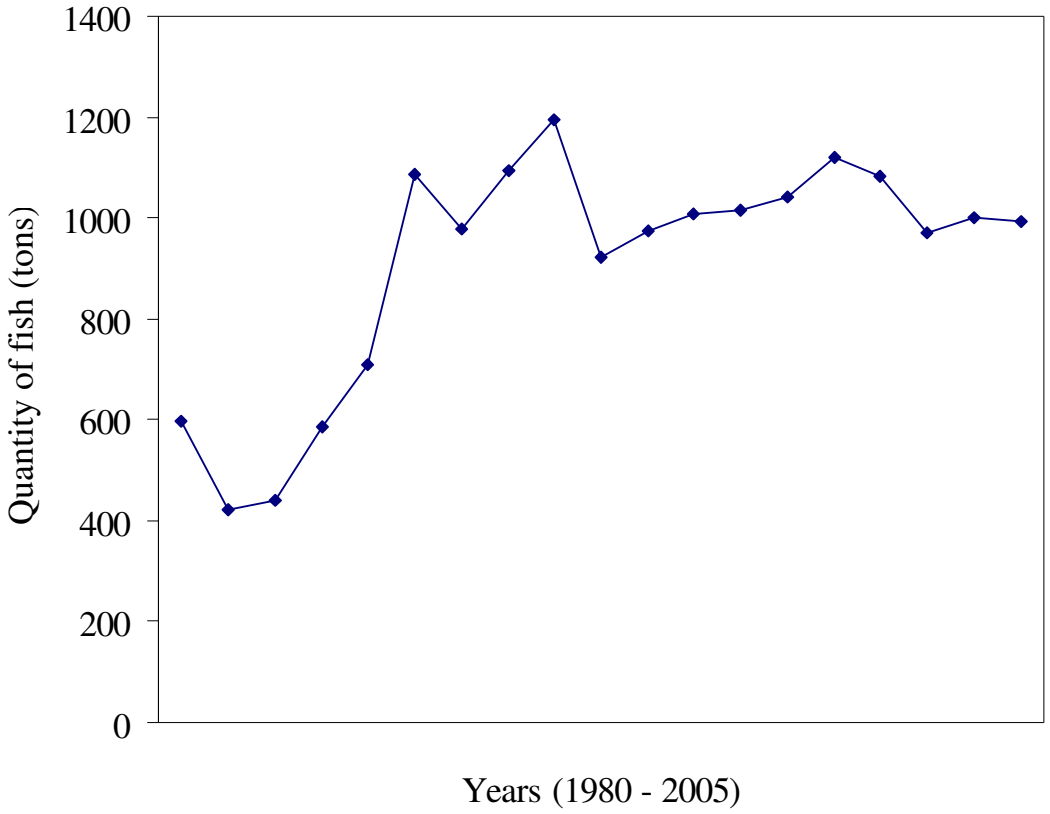


Figure 3.24 Aquaculture production in Kenya (Source: Department of Fisheries data)

Aquaculture is constrained by the following factors; technology, feeds availability, trained staff and the failure of fish farmers to perceive it as a commercial. In addition, the following constraints are also critical:- limited budget for aquaculture development, Lack of adequate and quality fish feeds and seeds, ineffective extension services, Lack of co-ordinated approach to aquaculture research and extension, Lack of farm-based research results for small-scale aquaculture development, Decreasing interest due to low returns and uncertainties, unclear policies on fish farming, Competition from capture fisheries, especially around Lake Victoria, Poor book keeping and farm management, Poor marketing arrangements.

The strategies for developing aquaculture should target the development of quality seeds and fingerling production; commercialisation of the aquaculture sub-sector; improvement on the farm management skills, improved co-ordination of aquaculture extension services, increased research into suitable aquaculture species and market research for potential aquaculture products

3.4.5 Causes of stock and catch declinein the lake basin

Catch decline is one indicator of over-exploitation, and has been a cause of concern especially for Nile perch, whose catch has gradually decreased since 1991 (only rising sharply in 1999 following the lifting of the ban on fish exports to the EU, then

falling off again). Besides the declining catches, the other two commonly applied stock assessment indicators – mean catch sizes and catch per unit effort – have also generally decreased in the past decade.

The declining catches are largely attributed to the use of small mesh nets, indiscriminate gears and mass-target fishing methods (such as trawling before 2000), which have been prevalent in Lake Victoria. There has also been a gradual reduction in mesh sizes of gillnets used in the lake in the last decade. There has also been rapid increase in number of fishers, boats and gear. Furthermore, reduction of state budgets led to reduction in staff, weakening enforcement of fisheries regulations.

Main causes of decline in riverine fisheries are destruction of natural spawning grounds due to gravel and sand mining, stabilization of riverbanks, chemical and organic pollution from industrial and agricultural activities.

3.4.6 Other issues of concern on fisheries

Other issues of concern in the fishery include non-optimal harvesting of living resources, ecosystem status and yields, deterioration in water quality, habitat destruction and alteration, loss of biotic integrity and threat to biodiversity, harmful algal blooms, introduction of alien species, inadequate capacity (human and infrastructure), destruction of fish breeding grounds and nurseries, cross-border fishing and conflicts as well as wetland reclamation (Odada *et al.* 2003).

In the recent past, emergent issues in the fishery include regional trade policies, value-addition to fishery products, poison fishing, regional collaboration and networking (surveys and assessment of ecosystem status), strengthening capacity to facilitate integrated management, and costs for regional actions. Odada *et al.* (2003) prioritised the issues of Lake Victoria fisheries by estimating the percentage gravity of the problems (Table 3.22)

Table 3.22 Prioritization of Lake Victoria issues

Issues	Immediate Cause	Sector activities	Root causes
Overexploitation of stocks	Increased effort Technological change	Fisheries Infrastructure provision	Economic Demographic Governance Technological
Excessive by-catch and discards *Destructive fishing practices	Increased effort Rent seeking behaviour Failure of monitoring and enforcement mechanisms		

*Issues considered relevant for causal chain and policy options analysis. Adapted from Odada *et al*. 2003

3.4.6.1 Non-optimal harvesting of living resources

Livelihoods of riparian communities have depended on the fisheries resources of Lake Victoria as the main source of their protein requirements (Fisheries Bulletins, 1959 – 2000). Fish catches have increased exponentially within the last forty years, giving the per capita consumption from below 3 kg in 1968 to 11.2 kg in 1991 and

decreasing to 7.1 kg in 1999 (CBS, 2001; Fisheries bulletin 1999; Greboval 1994). The gross per capita consumption of fish from Lake Victoria basin decreased between 1989 and 1999 due to increased exploitation pressure and intensification on fishing effort.

Nile perch, *Lates niloticus* (L.) was introduced into Lake Victoria from several sources in the late 1950's and early 1960's. Kenya executed the introduction from Lake Turkana Nile perch (Odero 1979) after it was evident that some specimens had been caught in the lake from the Uganda side (Hamblyn, 1959). Uganda introduced Nile perch from Lake Albert. It took up to ten years for the species to pick up in the lake. In the 1950's, Nile tilapia and other three-tilapiine species were introduced into the lake. Nile tilapia, *Oreochromis niloticus* was introduced into Lake Victoria around 1954 from Lake Turkana on the Kenyan side. From 1975 Nile perch and Nile tilapia have been present in the fishery in significant quantities, which has expanded the fishery to commercial status as evidenced from export figures. The catches of the endemic cyprinid has overtaken the catches of Nile perch in the recent past.

Indicators of overfishing in the Nile perch fishery are: reduction in age/length at maturity, high mortality (especially caused by fishing pressure), reduction in CPUE, reduction in mesh size of nets used and an increased proportion of immature fish in the catches (Bwathondi *et al*., 2001). Table 3.23 presents some of the findings from frame surveys on the changes in fishing and landing facilities.

Table 3.23 Fishing and Fish Landing facilities in Lake Victoria, Kenya (From Frame Survey Results, 2006)

		Kenya			Whole lake		
		YEAR			YEAR		
	Description	**2000**	**2002**	**2004**	**2000**	**2002**	**2004**
1.1	Number of landing sites	297	306	304	1,492	1,452	1,433
2.1	Bandas	80	72	76	166	133	128
2.2	Cold rooms (working)	1		3	10	10	8
2.3	Cold rooms (Non working)	1	2	6	1	30	46
2.4	Pontoon/Jetty	9	5	11	75	41	43
2.5	Fish stores	16	12	13	108	42	40
2.6	Electricity supply	29	15	12	65	60	56
2.7	Toilet facilities		150	179	0	265	294
2.8	Portable water		29	22	0	51	93
2.9	All weather roads	60	102	68	335	399	371
2.10	Boat repair facilities	51		149	496	363	407
2.11	Net repair facilities	51		107	480	355	329
3.1	Fisheries staff resident		22	39	65	94	88
4.1	No. of fishers	38,431	54,163	37,348	129,305	175,890	153,066
5.1	No. of landing sites with BMUs				0	0	466
6.1	Total No. of fishing crafts	11,515	12,209	12,284	42,493	52,481	51,712
6.2.1	No. using outboard engines	626	692	860	4,108	6,552	9,609
6.2.2	No. using inboard engines	15			90		
6.2.3	No. using paddles	7,561	6,820	6,560	32,032	35,720	33,405
6.2.4	No. using sails	3,313	4,697	4,858	6,304	9,680	8,672
6.3	**Craft types**						
6.3.1	Dugout	3	29	7	966	566	423
6.3.2	Parachute	1,501	1,966	2,394	6,912	7,841	8,138
6.3.3	Sesse flat at one end	951	1,625	1,445	11,126	16,147	16,288
6.3.4	Sesse pointed at both ends	7,903	8,499	8,304	22,359	27,248	25,076
6.3.5	Rafts			128	0	2	1,478
6.3.6	Other/Unspecified	1,127	90		1,156	672	189
7	**Transport crafts**						
7.1	No. Transport crafts	409	508	352	1,958	2,380	1,714
8	Derelict crafts						
8.1	No. Derelict crafts	1,876	2,467	1,906	7,465	9,203	11,335
9	**Fishing gears**						
9.1	Gillnets by size						
	Total No. of gillnets <5"	33,544	28,527	28,996	113,177	178,205	142,618
	Total No. of gillnets >5"	99,821	102,181	161,760	537,476	805,879	1,090,434
	Total No. of all gillnets	133,365	130,708	190,756	650,653	984,084	1,233,052
9.2	Dagaa fishing gears						
	Total small seines	12,387	2,097	3,048	18,112	8,236	8,601
9.2.5	Scoop net		12	14	809	1,379	842
9.3	Hooks						

		Kenya			Whole lake		
		YEAR			YEAR		
	Description	**2000**	**2002**	**2004**	**2000**	**2002**	**2004**
9.3.1	No. of Hook and line/Handline hooks	34,313	12,172	13,432	53,205	58,123	40,953
9.3.2	No. Long line hooks	1,039,893	2,562,066	2,045,605	3,496,247	8,098,023	6,096,338
9.4	Other gears						
9.4.1	Beach/Boat seine	5,803	1,157	869	7,613	3,491	3,355
9.4.2	Cast net	4,548	102	78	5,887	1,095	803
9.4.3	Monofilament			58	0	0	5,944
9.4.4	Traps/Baskets	3,179	2,311	1,846	17,112	9,122	7,805
9.4.5	Other/Unspecified	1,649			1,720	312	211

The major indicators in a healthy fishery are the length at first maturity, growth rate, fecundity egg size, survival rates and mortalities, shifting mesh sizes, CPUE and proportion of immature fish in the population.

The length at first maturity has been changing for both Nile tilapia and Nile perch. In Nile tilapia it has been observed to increase while in the case of Nile perch it has reduced (Ogari & Asila 1992; Ojuok 1999).

3.4.6.2 Ecosystem status and yields

At the peak of water hyacinth invasion, populations of *Protopterus aethiopicus*, and *Clarias gariepinus* were abundantly available inside the water hyacinth mat while *Oreochromis niloticus* would be found at the brinks of the mat. The water hyacinth cover had two advantages in this respect, one there was plenty of macro-invertebrates, which formed good food for the three main fish species and two, the mat formed an aggregation, shielding fish species from predation particularly their young.

Standing crop of Nile perch from bottom trawl indicates a lake wide mean of 10.01 tonnes per square kilometre. The standing stock was estimated at 694,000 metric tonnes in 1999 decreasing to 628,000 metric tonnes in 2000. Acoustic surveys indicated that the Nile perch populations in the lake stood at 790,000 tonnes in August 1999 decreasing to 530,000 metric tonnes in September 2001 (Cowx, 2001). The small pelagics (mainly *Rastrineobola argentea* and Haplochromines) increased from 350,000 tonnes in August 1999 to 1,200,000 tonnes in September 2001. Overall, there had been a decline in biomass index from 2.1 million tonnes in August 1999 to 1.5 million tonnes in September 2001.

Size structure of the Nile perch populations in the different regions determined from trawl surveys was dominated by younger size groups. A very high proportion of these catches are below the size at maturity. The sizes are decreasing due to heavy exploitation pressure from intensive fishing using different types of gear. It is estimated that most of the Nile perch harvested are immature.

The size at first maturity for Nile perch in the Nyanza gulf was reported at between 50 – 55 cm and 80 – 85 cm for males and females respectively (Hughes, 1992).

Fifty per cent maturity for male Nile perch in the Nyanza gulf was observed at 74 cm TL while for females it was noted 110 cm TL using 1978 – 1984 data (Asila & Ogari 1988). A decrease in fifty per cent maturity for Nile perch was observed at 55 cm TL for males and 70 cm TL for females (Asila, 1992). Most recent data (1997 – 1998) indicate that the fifty per cent maturity for males was noted at 59 cm TL while the one for females could not be determined because of too few specimens from the sampling. The size at first maturity was also noted at 51 cm TL for males and 91 cm TL for females. Similar observations have been made for Uganda and Tanzania on Nile perch.

The size at first maturity for *Oreochromis niloticus* was observed at 22.3 cm TL for males and 23.7 cm TL for females (Ogari & Asila, 1992). Most recent data indicate that the length at first maturity for *Oreochromis niloticus* is 26.2 cm TL for males and 24.3 cm TL for females. Fifty per cent maturity for males was observed at 33 cm TL and at 29 cm TL for females (Ojuok, 1999).

The size of catch in relation to size at maturity and total mortality rates are clear evidence of unsustainable tendencies in the fisheries and immediate action is needed to prevent overfishing. The length distribution for *Lates niloticus* and *Oreochromis niloticus* for different sizes of gill net indicate that the appropriate mesh sizes for the two fisheries is 152 mm.

3.4.6.3 Fisheries potential from the main lake

The standing stock for Nile perch in Lake Victoria was estimated at about 650,000 metric tonnes while the standing stock for *Haplochromis* species and *Rastrineobola argentea* stood at 700,000 metric tonnes. About fifty per cent of the Nile perch population is composed of juvenile fish. The current level of exploitation over-stretches the stocks of Nile perch and *Rastrineobola argentea* judging from maximum sustainable yield (MSY) of Nile perch and *Rastrineobola argentea*. In addition, the *Rastrineobola argentea* forms one of the main food resources for Nile perch. Exploitation of both species for human consumption puts unnecessary strain on the ecosystem that calls for precautionary measures.

All the data collected in the recent past indicate that the fishery is over-exploited and there is need to take immediate action against over-exploitation particularly the Nile perch stocks, the collapse of the fishery is imminent.

Socio-economic changes that have been occurring in Lake Victoria in the last two decades are commercialisation of the fishery; development of export and fishmeal market based on Nile perch and *Rastrineobola argentea*; increased industrialization of the fishery as evidenced from foreign exchange earnings to the country; higher value of the fishery in its contribution to GDP; increased employment in fish production and processing; better incomes to fish factories and fisherfolk and threat to food security (Abila, 2000).

There has been increased employment in the fisheries (harvesting sector to the export). More middlemen have joined the fisheries sector. Bokea and Ikiara (2000) estimate that 798,000 people are now employed in the fisheries sector directly or indirectly. Those directly employed rose from 10,000 in 1973 to 40,000 in 1998.

According to a recent frame survey, the number of fishermen offering their labour to the fishing industry in Lake Victoria stood at 153,066 (Table 3.23).

Threats to food security are imminently viewed as multidimensional. If the current exploitation levels are not controlled then the fishery is likely to collapse as a result of high current exploitation levels. Secondly local people have been constantly edged out of production, pricing, marketing and processing of fish. Traditionally women were actively involved in the processing and marketing of fish. Male actors now dominantly replace women out of their traditional roles. The third factor is that the unrestricted trade has contributed to food insecurity and reduced nutrition as families opt to fetch the good money from the fish export industry. The fourth factor is the lack of alternative sources of protein within the lake region. Allied to this fact is the lack of alternative sources of income within this region.

3.4.6.4 Fishing gear and fishing methods in Lake Victoria

Exploitation of fish in Lake Victoria utilise different fishing methods and gear. There are seventeen different fishing methods applied in the lake. The most common are passively set gill nets, mosquito seine nets, lift nets, beach seine nets, long line, hand line and traps. Results of frame survey 2004 from the three countries reveal that gill nets and long line were most popular in the three countries (Table 3.23).

3.4.6.5 Habitat destruction and alteration

Wetland reclamation, sand mining at river beds, erosion of the river banks, diversion of river channels (River Sondu-Miriu), infestation of water hyacinth and indiscriminate macrophyte harvesting alters the habitat and at times displaces fish species. A more recent reduction in lake level can sometimes lead to loss of species as had been case with increase in lake level in 1964 that displaced *Oreochromis esculentus* from the main lake (Welcomme 1970).

3.4.6.6 Loss of biotic integrity and threat to biodiversity

Lake Victoria, a haven of fish biodiversity, currently focuses on three species for its fishery namely Nile perch (*Lates niloticus*), Nile tilapia (*Oreochromis niloticus*) and the endemic cyprinid *Rastrineobola argentea* forming about 99% of the fish landings in Kenya part of Lake Victoria.

3.4.6.7 Introduction of alien species

Lake Victoria catchment has seen introductions of alien species of fish namely the thriving Nile perch (*Lates niloticus*) and Nile tilapia (*Oreochromis niloticus*). These two species currently forms the backbone of Lake Victoria. Nile perch introduction led to commercialisation of the fishery apart from upsetting the ecological stability of the lake. In future, however, there is need to consider the likely impacts of an alien species before introductions are made into the fishery. Future introductions should consider ecological implications before implementation.

3.4.6.8 Wetland reclamation

Yala Wetland in the Lake Victoria basin has recently been reclaimed for agricultural activities by Dominion Group of Companies, destroying its potential as fish habitat, particularly for the endangered fish species. Wetland reclamation destroys the

habitat for fish breeding and nursery grounds. It also exposes fish to predation. Reclamation of wetlands also increases the siltation of riparian waters. There is need to create awareness of the dangers of wetland reclamation to the people living within the hinterland of wetlands.

3.4.7 Regional fish trade policies

Nile perch has often found ready market in the Democratic Republic of Congo and Western Uganda where smoked fish is often preferred. Tanzania has been selling their fish to Kenya and likewise Uganda. More often than not these have transacted in the real market where restrictions have been put on the fish landing in the originating country.

There is need to enact stronger regional policies for trade to eliminate real market trade without imposition by the controlling authorities. This will assist in eliminating conflict in resource use currently rampant in the riparian states. It is also hoped that the establishment of COMESA will work towards eliminating trade barriers existing within the region.

3.4.8 Value-addition to fishery products

It is evident that the stocks of fish from Lake Victoria are on the decline. Fish exports to Europe and Far East have comprised mainly fillets. Value-addition of fish exported from Lake Victoria, could generate maximum benefits from the small amount of fish landed. Innovative approaches to diversification of the fish products would boost earnings from the fishery.

3.4.9 Poison fishing

Instances of poison fishing had been sporadically reported in Lake Victoria. The major chemicals reported were aciricides and related biocides. The fishermen ought to be made aware of the effects of using such chemicals in an ecosystem. The results of the widespread use such poison fishing led to the ban of fish exports from Lake Victoria between 1999 and 2000.

3.4.10 Regional collaboration and networking (surveys and assessment of ecosystem status)

Estimates of fish stocks are essential for planning and development of Lake Victoria fisheries. Results of surveys to determine the stock abundance cannot be taken in one or two countries without involving the others. Besides after the collection of data from such surveys synchronization of results gives credibility to the information derived out of such exercises. There is need for regional collaboration and networking between the partner states particularly in cases of surveys and assessment of the ecosystem.

3.4.11 Strengthening capacity to facilitate integrated management

Catch statistics are essential for planning and the management of the lake. Data on the catches in the fishery has been continuously taken in Kenya while in the two countries; lack of personnel has been a hampering factor since 1993. Regular patrols are also essential to ascertain compliance with the regulations. Capacities, both human and equipment, should be financed at the national and the regional levels to improve the management of the lake.

3.4.12 Costs of regional actions

Illegal mesh sizes have been rampant within the fishery in the past. Cases of piracy and net thefts have also been a source of conflict between different fishing and interest groups. Such cases can only be abated if the three riparian agree on common actions. Such actions could involve for example common patrols along the borders. It is therefore pertinent that the costs of such actions are borne by the partner states to improve the management of the fishery within Lake Victoria.

3.5. Invasive species in the Lake basin

The main introduced invasive species are Nile perch and Water hyacinth. Striga weed is also problematic in the agricultural sector.

3.5.1. Nile perch

Nile perch, a large centropomid piscivore that can reach over 2 meters in length, was introduced into Lake Victoria from Lakes Albert and Turkana during the 1950s and 1960s to compensate for depleting commercial fisheries, by converting low-value haplochromines into higher-value and more easily captured fish (Fryer 1960, Ogutu-Ohwayo 1990, 1993,Witte *et al*. 1999). Although many fish stocks in Lake Victoria had declined before the expansion of the Nile perch population, the 1980s roughly coincided with a drastic decline in populations of many indigenous species (Ogutu-Ohwayo 1990, Kaufman 1992, Witte *et al.* 1992a, 1992b; Kaufman *et al.* 1997). Particularly devastating was the disappearance of more than 50% of the non-littoral haplochromine cichlids or about 40% of the endemic haplochromine population. The species changes in Lake Victoria are notable from the 1950s through the 1970s and the 1990s, particularly with the introduction of Nile perch. The food web in Lake Victoria also changed significantly as a result of introduction of Nile perch (Figures 3.25, 3.26).

Table 3.24 Summary of the fish species found in landings

Species	Percentage of total catch by numbers		
	Kenya (7 Stations)	**Uganda (10 stations)**	**Tanzania (16 stations)**
Oreochromis esculentus	46.7	52.5	18.0
Oreochromis variabilis	14.9	20.2	3.9
Haplochromines	2.6	1.9	12.7
Labeo victorianus	14.7	2.4	31.9
Bagrus docmak	8.0	9.0	15.9
Barbus altianalis radcliffi	1.5	1.8	0.9
Momyrus spp.	6.0	3.7	3.3
Clarias gariepinus	1.5	1.8	0.9
Schilbe intermedius	2.4	0.2	4.8
Bracinus jacksonii	1.1	5.8	2.6
Synodontis spp.	0.0	0.0	0.2
Protopterus eathiopicus	0.5	1.0	0.5
Other species	0.1	0.2	4.8

* gill net data for Lake Victoria at recording stations in Kenya, Uganda and Tanzania in 1957. Source Balirwa *et al.* (2003)

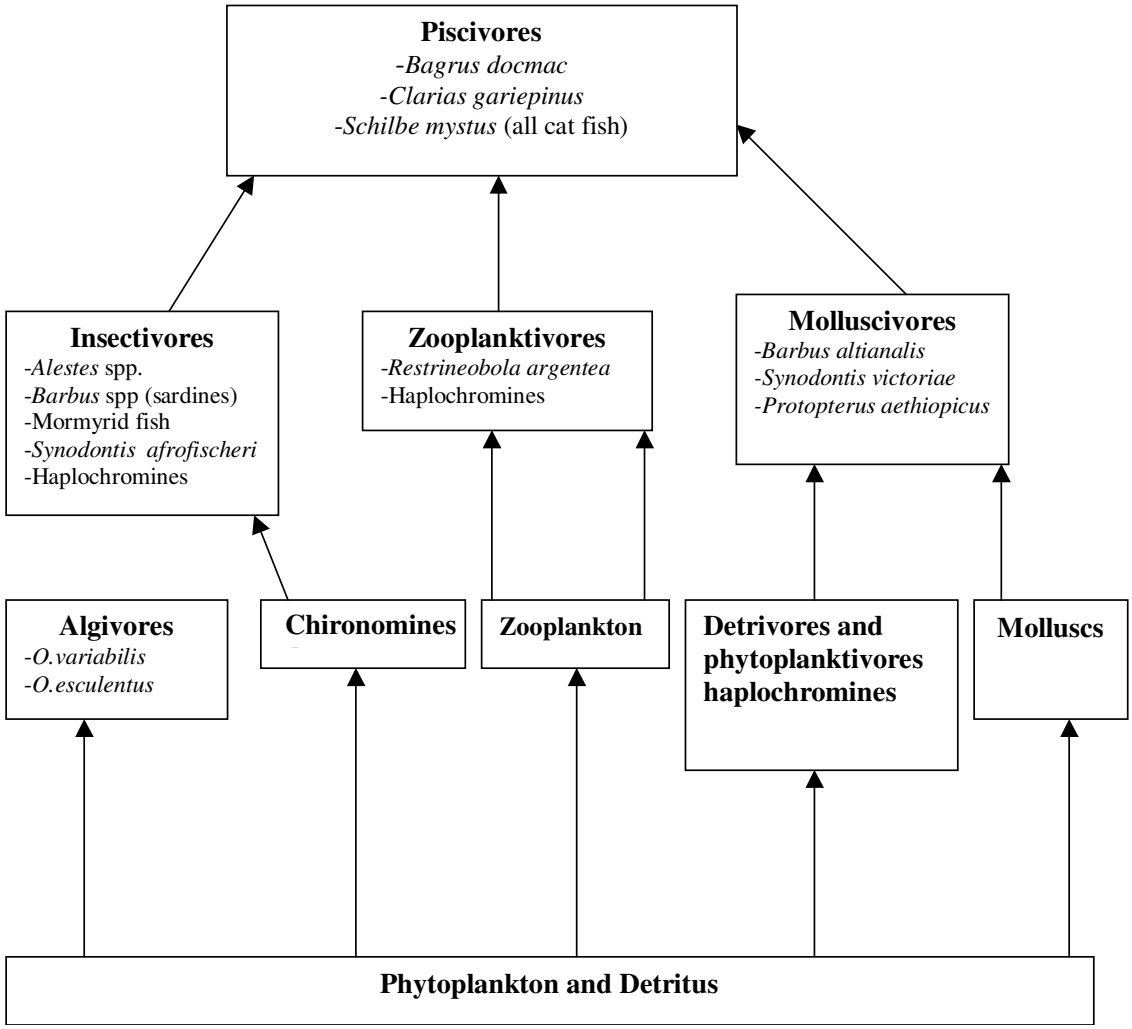


Figure 3.25 Food web in Lake Victoria prior to introduction of Nile Perch (Witte *et al.* 1992b).

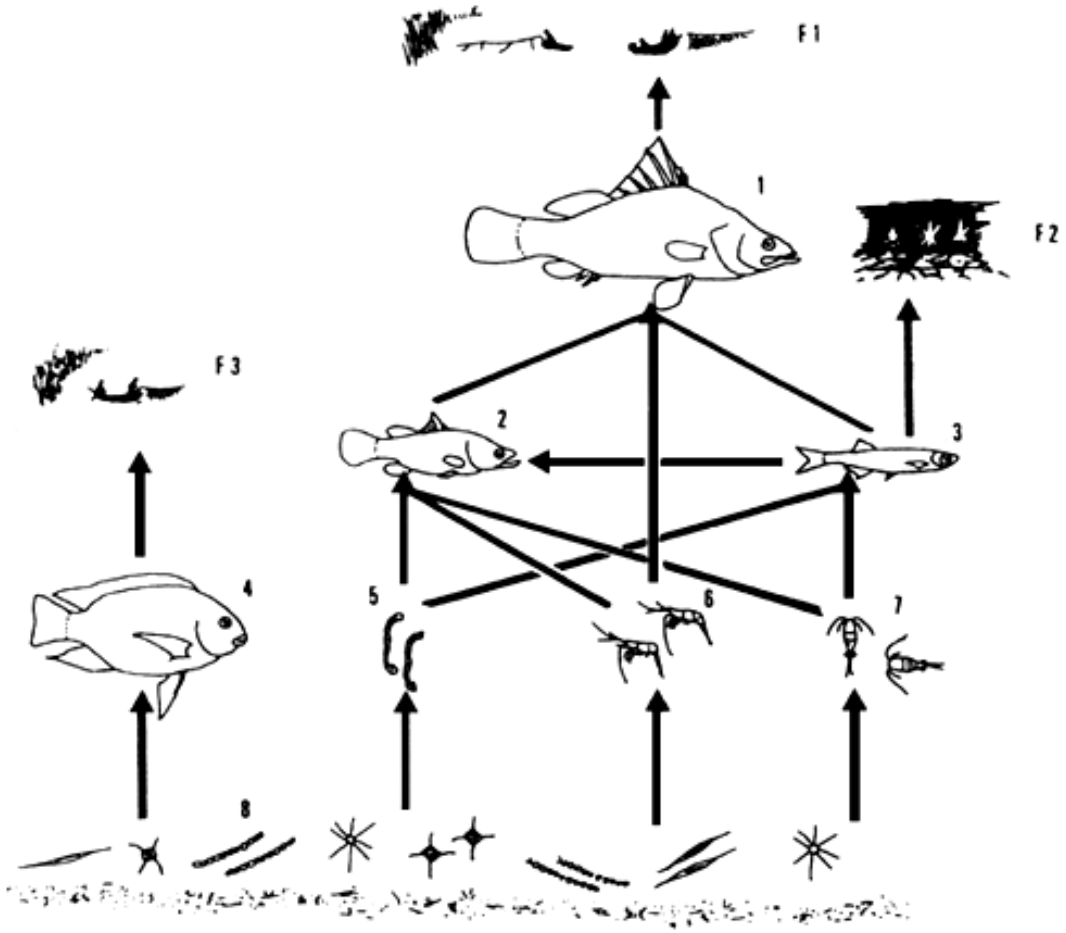


Figure 3.26 Food web in Lake Victoria after the introduction of Nile Perch (Witte *et al*. 1992b). 1: adult *Lates niloticus;* 2: juvenile *Lates;* 3: *Rastrineobola argentea*; 4: *Oreochromis niloticus*; 5: insect larvae; 6: *Caridina nilotica;* 7: zooplankton; 8: phytoplankton and detritus.

3.5.2. Water hyacinth

3.5.2.1. The status of water hyacinth in the Lake Victoria basin

*Eichhornia crassipes (*Water hyacinth) is native to South America. This non-indigenous vegetation appeared in Lake Kyoga, Uganda, in 1988 and in Lake Victoria in 1989 (Twongo *et al.* 1995). Water hyacinth is a flowering plant introduced into Lake Victoria through River Kagera. The weed doubles in mass in 11-18 days. It is free floating and migratory or submerged, depending on the sub-strata. It is sustained in Lake Victoria through high nutrient input from the catchment.

The weed became firmly established along the Nile, and in Lakes Victoria, Naivasha, Kyoga, and Albert, in two distinct forms: as stationary fringes along shorelines and as mobile mats. The weed rapidly increased in Lake Victoria, achieving its peak in 1998 (Figure 3.27). In the Ugandan waters of Lake Victoria, stationary fringes were estimated to cover 2,200 hectares along 80% of the shoreline by 1995 (NARO,

2001). Water hyacinth invasion had significant socioeconomic and environmental impacts, including disruption of transport, fishing, and fish marketing activities; disruption of lakeside recreational business; reduction of water supply; negative impacts on water quality for humans and livestock; and spread of waterborne diseases (Twongo, 1996, NARO, 2001; Njiru *et al.* 2002). Following biological and mechanical control measures, the weed population has gradually declined and is no longer regarded as a major problem in the lake.

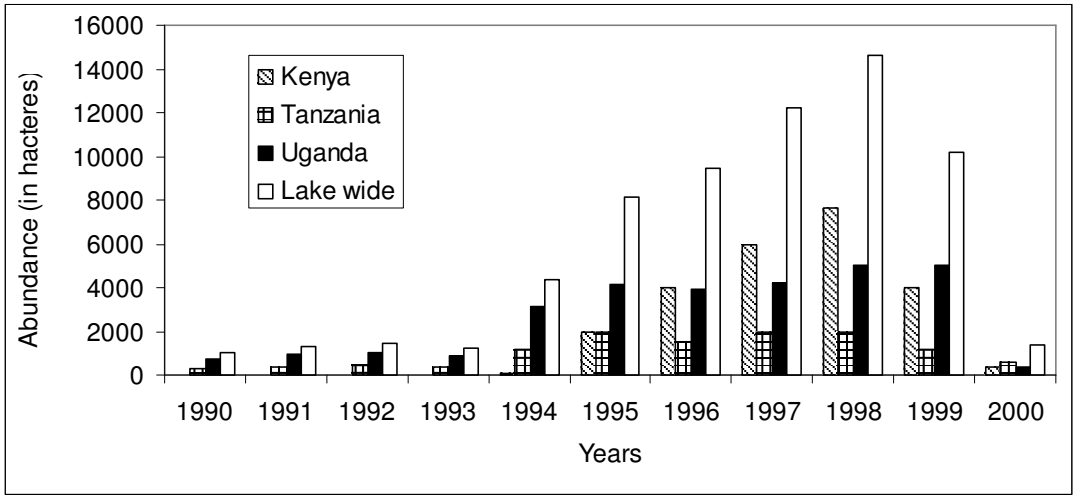


Figure 3.27 Evolution of the water hyacinth in Lake Victoria

3.5.2.2. Long term management of the water hyacinth

The long term components of a Water hyacinth management strategy are biological control and improved land use management of the upland sediment and nutrients. According to Othina *et al.* (2003), control of the water hyacinth was achieved via among others; biological control method using *Neochetina eichorniae* and *Neochetina bruchi* and the shading effects from the adjacent vegetation during the succession. In the medium term a well managed strategy is to employ biological control.Immediate quick fixes of chemical control (as has been done in Uganda) would have a huge negative impact on the already fragile ecological balance of the Lake. The major long term action requires substantial financial resources. For instance tertially treatment of wastewater will involve the use of constructed wetlands designed to reduce nutrient loads.

3.5.2.3. Economic potential of the water hyacinth

Although the water hyacinth is 95% water and has limited nutritive value due to fibrous tissues it can still be transformed into several useful products using simple methods and facilities namely;

a) Fodder: has 20% crude protein and could be used as fodder for pigs and poultry
b) Dry fuel: Initial drying and then briquetting by compression

c) Biogas production: decomposition for the production of biogas. Promising results from the Ugandan Luzira Prison/French Embassy project
d) Composting: Use on land as green manure and mulching material
e) Production of paper: Promising results from the Bangladesh experiment with which indicate the need to blend pulp to produce good quality paper
f) Furnature and handcraft: The plant can be used to make a variety of reinforced household furnature including chairs, tables etc.
g) Production of yarn, ropes, building boards: stem fibres of the plant are used to make ropes.

3.5.3. Other invasive weeds (e.g. Striga)

Other invasive weeds in the lake basin include; *Striga, Duck weed, Lantana camara, African marigold, Solanium nigrum, Mexican marigold etc. Striga* (or witch weed) has the greatest adverse impact on agricultural productivity in the Lake Victoria basin. Striga is a parasitic plant that affects cereal crops in many parts of Africa, resulting in crop yield loss of 30-100%. Plants affected by striga are dwarfed, under-nourished and hardly exceed 1 foot tall. The weed attaches on the host plant roots, drawing the plant's nutrients and causing stunting of the host crop and loss of yield. Striga is very prolific; each striga plant can produce upto 50,000 seeds, which lie dormant (sometimes for for up to 15 years) in the soil till a cereal crop is planted which induces it to sprout. Striga may be controlled by good farming practices using a combination of methods, including; effective crop rotation, inter-cropping, for example with desmodium, mechanical removal before it produces seeds and planting other 'false' crops off-season to induce its germination.

3.6. Biodiversity conservation

International conventions such as the Convention of Biological diversity (CBD) are vital legal instruments that address issues of sustainable development. These complement efforts at national level, to protect flora and fauna and reduce environmental degradation. Despite the existence of these conventions and other supporting laws, many human activities still challenge the continued survival of the flora, fauna and a healthy environment.

3.6.1. Faunal biodiversity within the lake basin

3.6.1.1 Amphibian communities

Among the amphibians the only ones recorded in the Lake Victoria basin are the anurans (frogs and toads) (Table 3.25). Many amphibian species inhabit wetlands around water bodies. Any negative impact on an aquatic system emanating from inshore must first affect amphibians before affecting the organisms in the water, such as fish. Although largely overlooked, amphibians can therefore act as excellent indicators in assessing the biodiversity of an area (Heyer *et. al.* 1994). Amphibians are probably the least studied vertebrate group in East Africa. The only detailed studies done in a few places of the basin to-date have been those carried out by Behangana (In Press), Kigoolo (1994) and Schiøtz (1999). Researchers such as Eggeling (1934) and Pitman (1974) carried out other incidental researches and collections. In general, amphibians are not among the most threatened species in Kenya (Table 3.26).

Table 3.25 Amphibians of Lake Victoria basin, Kenya. (Adapted from P. Kansoma eds). X = present; - = no data.

Species /Sites	L. Sare	L. Kanyaboli	L. Nyamboyo	R. Yala	R. Nzoia	Yala swamp
Xenopus laevis	X	X	X	X	X	-
Afrana angolensis	X	X	-	-	-	X
Phrynobatrachus matalensis	-	-	-	-	-	X
Ptychadena chrysogaster	-	-	-	X	X	-
Kassina senegalensis	-	-	-	-	-	X
Bufo latifrons	-	-	-	-	-	X

Table 3.26 List of African countries with large number of threatened amphibian species (IUCN: red list of threatened animals, 1996).

Country	Threatened Amphibian species
Uganda	0
South Africa	9
Cameroon	1
Kenya	1
Tanzania	1
Madagascar	1
Seychelles	4

3.6.1.2. Reptile communities

Recent research indicates that there are no members of orders Rhynchocephalia and Amphisibaenia among the identified reptiles in the Lake Victoria basin (Table 3.27). In addition, due to their cryptic nature and the fact that some are poisonous, reptiles have been less studied than mammals and birds, therefore, lists of this taxon are not complete. Most reptiles are specialised and tend to show high specificity to certain habitats and are therefore important to include in any biodiversity analysis. Some reptiles such as crocodiles and the Nile Monitor are veracious predators of fish.

Table 3.27 Reptiles of the Lake Victoria catchment. (Adapted from P. Kansoma eds. X=present; - = no data)

Species / Sites	L. Sare	L. Kanyaboli	L. Namboyo	R. Yala	R. Nzoia	Yala swamp
Cansus lichtensteinii	-	-	-	X	-	-
Crotopholpeltis degeni	x	X	X	-	-	-
Grayia smythii	x	X	X	X	X	-
Grayia tholloni	x	X	X	X	X	-
Leptotyphlops conjuctus	-	-	-	-	-	X
Naja melanoleuca	-	-	-	X	X	-

Naja nigricollis	-	-	-	-	-	X
Philothamnus carinatus	-	-	-	-	-	X
Philothamnus heterolepridotus	-	-	-	X	-	X
Philothamnus niticlus	x	X	X	-	-	X
Philothamnus semivariegatus	x	X	X	-	-	
Psammophis mossambicus	-	-	-	-	-	X
Python sebae	-	-	-	-	-	X

3.6.1.3. Mammalian communities

The main species identified in the Lake Victoria basin are shown in Table 3.28. Some mammals are terrestrial (live on land); others arboreal (live in trees) while others are fossorial (live underground). Other mammals such as the otters, Sitatunga and the Hippopotamus are largely aquatic or use wetlands most of the times as a habitat or as feeding grounds. Traditional studies on mammals have mainly concentrated on the larger forms such as elephants, buffaloes and lions, down to the size of primates. Most of these studies have documented the mammals of rangelands and forests, and very few of the wetlands and aquatic habitats. This has been true for the Lake Victoria basin (Table 3.28).

As such, what has been mostly recorded and studied of the mammalian fauna in the past have been the Sitatungas, some primates, hippos and otters. A few studies that have documented these small mammals in a few locations include those carried by Eggeling (1934). This has been the first ever-detailed study of aquatic fauna of the Lake Victoria basin, covering the littoral zones and the immediate ecotones. The research covered several shorelines, rivers and associated wetlands as well as satellite lakes. Even then, these sites have been poorly surveyed.

Table 3.28 Mammals of Lake Victoria basin, Kenya. (Adapted from P. Kansoma eds. X = present; - = No data)

Species / Sites	**L. Namboyo**	**L. Kanyaboli**	**L. Sare**	**R. Yala**	**R. Nzoia**	**Yala swamp**
Cercopithecus aethiops	-	-	-	-	-	X
Epomophorus wahlbergi	-	-	-	-	-	X
Hippopotamus amphibious	x	-	X	-	-	X
Kobus defassa	-	-	-	-	-	X
Phacochoerus eathiopicus	-	-	-	-	-	X
Redunca redunca	-	-	-	-	-	X
Tragelephus scriptus	-	-	-	-	-	X
Tragelaphus spekei	-	-	-	-	-	X

3.6.1.4. Avian communities

Bird distribution is influenced by human activities, availability of food and seasons. Bird species that are endemic to papyrus swamps include vulnerable Papyrus yellow warbler *Chloropeta gracilirostris*, the endangered Papyrus Gonolek, Laniarius *mufumbiri* (Collar *et al.* 1994), the Papyrus Canary *Serinus koliensis,* Carruthers's Cisticola *Cisticola carruthersi* and white-winged warbler *Bradypterus carpalis*. These birds are contained in the East African Red Data list of birds (Bennun & Njoroge, 1996).

The dominant families observed in selected Lake Victoria wetlands include: Sternidae 36.12% and Scolopacidae (18.23%) with diversity indices of 0.71 and 0.64 respectively and a total of 49 bird species (Appendix 1). The benthivores dominate Lake Simbi and the Kano plains while the non-selective feeders are found in all areas but in smaller numbers, while in the Sondu-Miriu wetland, omnivores dominate. In some Lake Victoria wetlands, piscivores dominate especially in Aneko, River Tako and Pengle while the omnivores dominate in the Rota, Dunga and the Sondu- Miriu.

The highest diversities and densities are in irrigation schemes of Kano. These are the main feeding grounds for aquatic fowl most of which concentrate in the primary ponds. Gulls dominate in the main Lake and in the interface zone while Hamerkops egrets and kingfishers are dominant in the inshore areas and the littoral fringes.

In the Sondu-Miriu wetland the most represented families are Ardeidae (46.82%)), Threskiornidae (18.46%) and Sternidae (16.5%). It is evident that seasonal rainfall patterns affect prey availability by causing water levels to fluctuate in shallow water habitats. Movement of the wading birds is a response to fluctuations in resource/ food availability. Once temporary side pools dry out, the birds concentrate near the Sondu- Miriu river edge while others move to rice fields at Kano and Nyamware, others concentrate at the Nyalenda sewerage treatment works.

The Sondu- Miriu river mouth harbours some of the most threatened endemic bird species such as; the Papyrus gonolek *Luniarus mufumbiri* and the papyrus yellow warbler *Chloropeta gracilirostris.*

3.6.1.5. Fish communities

Fish community within the lake basin consists of over 300 cichlid species and about 39 non-cichlid species inhabiting waterbodies. These fishes have been largely used for their food value but recently the ornamental aspects have been gaining prominence. Collection have been made of the haplochromine species to the United States of America and Europe due to their brightly colours. Some species are threatened with extinction and refugias ought to set up to remedy the disappearance.

Four alien tilapiines (O*reochromis niloticus, Oreochromis esculentus, Oreochromis leucostictus, Oreochromis melanopleura* and *Tilapia zillii*) were introduced into Lake Victoria in the late 1950's.

3.6.2 Floral biodiversity

Lake Victoria basin is endowed by a variety of plant species that are used for medicine, firewood, construction, vegetables and other viable uses. Can be broadly classified into two main groups as terrestrial and aquatic plants.

Aquatic plants (macrophytes) are higher plants that grow in ecosystems whose formation has been dominated by water and whose processes and characteristics are largely controlled by water. The most common macrophytes include *Ceratophyllum demersum, Najas horrida, Nymphaea lotus, Trapa natans, Eichhornia crassipes, Typha domingensis and Phragmites australis.* Protection of aquatic vegetation is known to contribute to conservation of fish species diversity.

Globally macrophytes are destroyed at an alarming rate leading to loss of biodiversity. Degradation of the plant community is caused by the demand for land for agriculture and settlement. In lake Victoria basin the situation is worsened by the high rate of population growth rate and open access system to areas where these plants occur. Invasion and proliferation of water hyacinth in the lake is also a threat to the endemic plants during succession. An example case is the disappearance of *A. nilotica* in the Kenyan portion of the lake (Kansoma in press).

Terrestial plants are plants found in non-aquatic ecosystems. The most common terrestrial plants are black jack, eucalyptus, Gravillea, etc.

These plants can be further classified by their usages as mentioned above, a classification that will be used in this text.

3.6.2.1 Medicinal plants

These range from herbs to large trees for curative purposes. Some are used a palliatives for different ailments.

3.6.2.2 Vegetable plants

These have traditionally been grown in smallholdings and some have been growing wild in wetlands areas. With reclamation of wetlands for human use these plants are threatened.

3.6.2.3 Other plants

Large trees in the natural forests have been used as a source of building materials for the construction of walls and roofs. Some have been used as a source of woodfuel since about 70 percent of the rural energy is derived from woodfuel.

3.7. Wetland Resources

3.7.1. The Status of Wetland Resources

Wetlands are defined as areas of land that are permanent or occassionaly waterlogged with fresh, saline, blackish or marine waters, including both natural and man made areas that support characteristic biota.This definition is adapted from Ramsar, (1971). The wetland resources of the Lake Victoria basin are defined to include floodplain and fringing emergent macrophytes often dominated by papyrus

Cyperus papyrus (Gichuki *et al.* 2001; Gichuki and Odhiambo, 1994). The definition of the wetlands also includes the shallow nearshore zone of the lake upto three metres deep. This zone supports rooted and floating macrophytes. The main wetlands within the Lake Victoria basin are;

i) The Yala Swamp (17 500 ha of wetland, including Lake Kanyaboli (1 050 ha), Lake Sare (500 ha) and Lake Namboyo (1 ha) and stretch 25 km from W-E and 15 km from N-S at the lakeshore.
ii) Nyando is situated at the mouth of the Nyando River at Nyakach Bay, extending back onto the Kano Plains. The Nyando Swamp measures 15 km from W-E and some 6 km from N-S.
iii) Sondu- Miriu occurs at the mouth of the Sondu River. Together with the Nyando swamp, the two swamps occupy about 10 000 ha.
iv) Gucha (=Kuja-Migori) Delta is also a deltaic swamp at the mouth of river Kuja Migori.
v) Mogusi River is located at the mouth of river Mogusi close to Homa Bay town.

Other small wetlands, including seasonally flooded areas and permanent swamps, occur on the upper courses of these rivers and their tributaries. The most important of these are found at the foot of the deep slopes on the west side of the Rift Valley, from the Cherangany Hills to the equator. One such wetland is Saiwa Swamp, which includes both floodplain and permanent swamp, occurs on the Nzoia River immediately North East of Kitale. This wetland is 20 km long from NW-SE and 1-5 km wide and extends to about 6000 ha. A small permanent swamp about 1000 ha is situated north of Nzoia River. A seasonal floodplain occurs on the Kimandi River, a tributary of the Yala River. This wetland covers 4800 ha.

3.7.2. Functional, economic and social values of wetlands

Wetlands in the Lake Victoria basin provide the following goods and services.

i) The emergent wetlands of Lake Victoria regulate the flow of water through their spongy underwater biomass and in the process contribute to water conservation.
ii) The wetland strip and retain incoming sediments and nutrients and thus buffering the lake from pollutants.
iii) Contribute to climate modification through evapotranspiration.
iv) Act as habitats of biodiversity including the rare Sitatunga (*Tragelaphus spekei*), the Shoe- bill, Crown cranes and swamp Warblers
v) Provided building materials for thatch, mat making and basket weaving as well as wetland soils and mineral products such as clay, bricks, ceramics, sand and salt.
vi) Flood plain wetlands are often used for grazing livestock especially during the dry season
vii) Nursery and breeding areas for juvenile fishes such as Tilapiines
viii) Recreation and tourism areas (sports/hunting)
ix) Water supply
x) Energy production in form of plant biomass (Gichuki and Odhiambo, 1994)
xi) Research and education
xii) Religious and cultural siginificance

Fringing wetlands regulate the quality of water entering the lake and are critical habitats for fish and other aquatic organisms. Overharvesting and burning of

wetland vegetation as well as conversion of wetlands led to changes in structural composition of surface water. Thus the water quality deterioration in Lake Victoria is partly attributed to encroachment on wetlands.

3.7.3. Threats to wetlands

In the recent past the Lake Victoria basin wetlands have undergone serious degradation. The sources of degradation include; excessive resource harvesting, overgrazing, and conversion for agriculture and industrial development. Currently, both the Yala Swamp, and the Nyando and Sondu Swamps on the Kano Plains are being drained for agriculture. It is estimated that at least 14 000 ha of the Yala Swamp can be made productive, and by 1980, 380 ha had been converted for rice production. On the Kano Plains, 900 ha had been converted for rice and sugar cane. Recent data indicate that a total of 2,300 ha has so far been reclaimed in Yala Swamp in Siaya District. being drained for agriculture. It is estimated that at least 14 000 ha of the Yala Swamp can be made productive, and by 1980, 380 ha had been converted for rice production. On the Kano Plains, 900 ha had been converted for rice and sugar cane. Recent data indicate that a total of 2,300 ha has so far been reclaimed in Yala Swamp in Siaya District. Emerging scenarios include the wetland ecosystems claiming parts of available land and displacing community in the low-lying land areas eg in Budalangi (Busia District). This perpetual annual disaster can be possibly attributed to poor land-use practices associated with population increase. In general the wetlands of Lake Victoria are under threat from;

i) Severe soil erosion
ii) Siltation of major rivers and lakes
iii) Planting of unsuitable plant species in the wetland areas
iv) Clearing of vegetation and cultivation along riverbanks and lake shores.
v) Introduction of alien species.
vi) Massive deforestation
vii) Reclamation of wetlands
viii) Over fishing in the lake waters
ix) Pollution of the water systems from agro-chemicals and urban effluent.

The loss of wetlands around the world is forcing wild birds to seek alternative homes in farm ponds and paddy fields bringing them into direct contact with chicken, ducks, geese, and other domesticated fowl (The Standard 14 April 2006) and thus possible transmission of diseases such as the avian flu.

3.7.4. Opportunities for wetlands

A draft wetland policy has been developed by National Environmental Management Authority. The process involved other stakeholders in the Wetland sector.
The goals of wetland policy are:-

i) End unsustainable exploitative practices in wetlands and halt the decline in their productivity.
ii) Maintain their biological diversity functions and values and establish principles whereby wetland resources can be optimally used and their productivity maintained.

The wetland conservation and management policy is based on the principles that;

a) Wetland resources form an integral part of the environment: their conservation must be pursued through an interaction between conservation objectives and national development strategies and activities.
b) Wetland conservation can only be achieved through a coordinated and co-operative approach involving all concerned people and organizations, in the country, including local communities.
c) The present negative attitudes and perceptions of people towards wetlands can be changed.

3.8. Wildlife resources

3.8.1. Status of wildlife resources

The wildlife resources within the basin are represented by migratory and residential bird populations, large mammals such as elephants, lions, buffaloes, cheetah, hippopotamus and the small mammals such as otters as well as reptiles such as crocodiles and monitor lizards and amphibians. The basin has been designated as an important Bird Area (IBA) with 70 IBAs such sites in the basin. Some of the endangered bird species are found in the basin. These are mainly the vulnerable Papyrus Yellow Warbler *Chrolopeta gracillostris* and Papyrus Gonolek *Laniarius mufumbiri.* The Sitatunga (*Tragelaphus spekei*) currently one of the endangered species is a largely aquatic animal and uses the wetlands in most of the times as a habitat and feeding ground. Wildlife management involves the conservation and utilization of wild animals. Lake Victoria catchment has two national parks; Mt. Elgon and Masai Mara, and one game reserve (Ruma). Under the management of Kenya Wildlife services, the aim of these parks is to conserve and sustainably manage the wildlife and protected areas of Kenya in partnership with the neighbouring communities and other stakeholders for the benefit of the people of Kenya and the global community.

3.8.1.1. Masai Mara

The Masai Mara National Reserve (MMNR) is a 1,510 km protected area in south-west Kenya. It is part of the world famous Serengeti-Mara ecosystem that covers over 25,000 km^2 of Maasai land in Kenya and Tanzania. It receives ample water from the tree-lined Mara River, a tributary of the Talek River. Lying at an altitude of c.1600 m, it is an area of undulating grassland savanna. MMNR is best known for its annual wildebeest and zebra migration that arrives from the southern plains of the Serengeti every July. This often comprises over one million animals that remain in the Reserve for several months over the dry season, before crossing the Mara River and returning to the Serengeti when the rains return. In addition, Lions, Elephant, Buffalo, Zebra, and Hippo roam in large herds while the topi, impala, and Coke's hartebeest are also abundant. The migration and the many other herbivores that reside in MMNR year round provide food for a wide range of large carnivores, including lion, hyaena, leopard and cheetah. This area supports one of the highest densities of large carnivores in Africa and is a major draw for international tourists.

Within its enormous diversity of mammal species, MMNR includes a number of endangered species. Most well known are the African elephant and the black rhino. Elephants are doing very well in and a round the Reserve, and their population currently numbers around 1500.

3.8.1.2 Ruma National Park

The park has equatorial climate. The wilderness offers a treat for nature lovers in terms of bird and game. The main game in this park consist of Cheeter, Lion, Bat eared fox, Jackals, Waterbucks, Hippos, Giraffes, Crocodiles, Impala, Dik dik, Thompsons and Grants gazelles. The main hotels in this area are; Takawiri, Rusinga Island hotel, Homa Bay Tourist Hotel, Mfangano Island Hotel, Hippo Back Lodge. Visitors can explore the interesting sites within this area such as Thimlich Ohinga, Gogo falls, Kanyamwa Escarpment, Mwarach Hills and Rusinga Island.

3.8.1.3 Lake Victoria

Lake Victoria is the second largest fresh water mass in the world. The lake has numerous islands (Mageta, Denda, Sifu, Ndere and Oyamo) inhabited by hippos, crocodiles, waterbucks, monkeys, monitor lizards, snakes and birds of various species. There are sport fishing activities on the Rusinga Isand and Takawiri Islands. Within this region visitors can explore the Takawiri Musical club. Within Kisumu there are various sport activities such as sport fishing, boating and cruise safaris. Overland tourism consist of tourism attraction sites such as Ramogi hill, a prehistoric site, the oxbow lakes (Kanyaboli, Sare and Namboyo), the sprawling Yala Swamp complex, the water falls at Kango along Yala, Rambula along Nzoia, Gogo along Kuja Migori and Odino falls in the Lower Sondu Miriu.

3.8.1.4 Mt Elgon National Park

Mount Elgon consists of a national park, one national reserve and several forest reserves. It is a very special and important ecosystem for the following reasons;

i) Mt. Elgon includes mountain and afromountain plant communities and is home to over 240 bird species.
ii) Mt. Elgon ecosystem is important to the local community as allocation of cultural sites and a source of traditional food and medicines. Many rural communities rely on the protected areas for products such as bamboo shoots and stems, firewood, medicinal plants, vegetables, pole wood, timber, honey and bush meat.
iii) About 1.7 million people rely on the Mt. Elgon ecosystem in both Kenya and Uganda.
iv) The ecosystem is a major catchment area for Nile basin, through Lakes Victoria and Kyoga, and the Turkwell and Lake Turkana system.
v) Natural and cultural resources on Mt. Elgon represent a shared heritage of great significance to Kenya and Uganda.
vi) Conservation of these resources requires active cooperation between the two nations and the used groups around the ecosystem.

A number of inconsistencies remain with negative implications for boundary management despite policy convergence on conservation and use of biodiversity. They include the following;

i) Environmental problems (ecosystem degradation, poaching, global warming) do not respect political boundaries.
ii) Transboundary collaboration and co-ordination is the main-strategy to assist in the management of Mount Elgon ecosystem.
iii) National policy is one essential level to be tackled.

iv) Local environmental policies and their implementation are influenced by policy scenario at the national level.
v) The Uganda Government and local communities have over the last 10 years been implementing the Mount Elgon Ugandan side of the Mountain (NORAD & IUCN).
vi) The Kenya Government in partnership with the Royal Netherlands Government and IUCN has established the Mount Elgon Integrated Conservation and Development Project. For the last six years, the project has worked to implement sustainable ecosystem management practices on the Kenya side of Mt. Elgon. Project activities operate at three levels: Park boundary, district and national level.
vii) The Ugandan and the Kenyan projects are both planned and established to tackle a range of strategies to conserve the Elgon ecosystem and promote sustainable development within its resource-dependent communities.
viii) Activities on both sides of the border have included agricultural extension programmes, environmental education, boundary marking and support for law enforcement within the contagious parks.
ix) Local people have been trained as extension workers to operate sustainable development programmes, which encourage local people to develop alternative sources of natural resources traditionally taken from parks.
x) In Uganda, support for district-level environmental planning was provided to the neighbouring districts of Mbale and Kapchorwa in order to raise the profile of ecosystem conservation within district planning strategies.
xi) In Kenya, the project works at district level with KWS and Forest Department. Achievements include institutional strengthening of a joint ecosystem management plan and coordination with district authorities.
xii) The project also co-ordinates at the national level with Forest Department and KWS headquarters on policy issues.
xiii) The Uganda Wildlife Authority and the Kenya Wildlife have established close linkages and are in the process of developing a joint management plan.
xiv) This will enable joint activities such as Law enforcement patrols; Tourism activities will be improved by this process; Uganda Wildlife Authority and KWS are formalizing plans for a Transboundary mountain trek, enabling hikers to ascend the mountain in one country and descend into the neighbouring one.

3.8.2. Social and economic values of wildlife

3.8.2.1 Contribution of wildlife sector to the economy

Kenya generated about Ksh. 42 billion from tourism: The money was generated mainly from wildlife tourism (ie expenditures of foreign tourists who travel to Kenya pursuit of wildlife experiences). Park fee to transportation and hotels.

3.8.2.2 Natural heritage for the Kenya

Wildlife provides powerful images that help define the very essence of our country: eg the lion (used in our coat of arms), elephant etc. Wildlife also figures prominently in art, legend, and ceremony. Wildlife has inspired such human activities as art, music, dance, drama, story-telling, and poetry. It also plays an important part in our spiritual lives, at the very least reminding us of the complexity and wonder of our world.

3.8.2.3 Recreational facilities

These include pastimes such as hunting, canoeing, or wildlife photography and bird watching

3.8.2.4 Indicator of health of the environment

Wildlife is an excellent indication of the health of the environment on which we depend, and that healthy wildlife populations and habitat are important to our social and economic well-being.

3.8.2.5. Source of food

Meat, warm sleeping skins, and horn used to make implements and weapons. The wild harvest for food, clothing, and income. From hunting, fishing, and trapping, while food taken from the bush can account for a high percentage of dietary needs.

3.8.2.6 Wildlife is important to natural processes

Wildlife and wildlife habitat play a vital role in the ecological and biological processes that are essential to life itself. Some of the biological processes in which wild species play a key role are pollinization, germination, seed dispersal, soil generation, nutrient cycling, predation, habitat maintenance, waste breakdown, and pest control. Birds, for example, can be important in controlling insect pests.

.3.8.3. Threats to Wildlife

3.8.3.1 Human wildlife conflicts

Animals especially the predators attack livestock while the herbivore raid fields of ripe maize just prior to harvest, destroying local livelihoods and placing people at risk of injury and death. This reduces local tolerance of elephants that are themselves injured and killed as a result.

3.8.3.2 Destruction of the ecosystems

Clearing (including the cultivation of grasslands), invasive plants and animals, fragmentation, inappropriate fire regime, inappropriate grazing pressure or infrastructure development may all be considered threatening processes

3.8.3.3 Use of chemicals

During the last few years there has been a great change in regional agriculture. Now farmers use chemical fertilizers, pesticides and insecticides that are leading to diseases in wildlife especially insects, birds and the aquatic fauna.

3.8.3.4 Lack of awareness

The environment and its related components have hitherto been neglected. Therefore even though the people of the area are aware of their surrounding flora and fauna, they have little awareness about the importance of conservation. Traditional activities like hunting or shooting of wildlife have still not been banned for instance in Tanzania.

3.8.3.5 Weak enforcement of the law

The rules and regulations that have been framed regarding the protection and conservation of natural resources have typically not been implemented properly due to weak law enforcement.

3.8.3.6 Insufficient inventories and data

In many areas, there is insufficient primary and secondary information about wildlife status, its genetic richness and habitat condition. Where some information does exist on biodiversity, it is usually not shared widely. Published data is also typically unknown to most people except the authors and a few academics. Moreover, a lot of the information remains on files as raw data.

3.8.3.7 Limited resources

Lack of adequate field staff and proper training of existing staff, combined with limited funds, means that they cannot perform their duties effectively.

3.8.3.8 Lack of research/ medical facilities

Limited or almost no research or medical facilities for animal health.

3.8.3.9 Other causes

These causes can be categorized as either indirect eg. poverty and little or lack of incentives. The main direct causes include natural hazards (drought, floods), lack of prey species, introduction of exotics (Nile perch, trout, carp etc), killing by herdsmen to protect their livestock

a) With population increase, parks and game reserves are becoming isolated islands of biodiversity imposing serious limitations on the traditional migration of animals and genetic exchange. There is need to ensure corridors are created and maintained to link wider, inter-connected systems.
b) Adequate buffer zones should be established around parks to absorb pressures from increasing human population on the wildlife resources.
c) The policies are silent on the nature of human activities around parks. Land uses that are compatible with conservation objectives should be identified, supported and promoted.

d) The involvement and participation of local communities in management, conservation and benefit sharing should be given greater attention. The knowledge of local people represents a capital asset for sustainable wildlife conservation and so capacity building and capacity exchange should be a continuing process.
e) Wildlife and local communities should be viewed as a continuum and not district entities. Wildlife management should therefore be inseparably linked with the local people.
f) Conservation policies should not exclusively focus on protectionism. Instead they should incorporate conservation education and awareness so that implications, benefits, costs and consequences of wildlife conservation can be fully interpreted, understood and respected.
g) The policies should enable the cultivation of partnerships to secure financial and human resources for wildlife management. This should involve the government agencies NGOs, CBOs, private sector, individuals, etc at both national and international levels.
h) Not all representative wildlife species and ecosystems are adequately protected. The policies should propose a review of the wildlife systems in the country to identify omissions.
i) Wetlands should be targeted as potential wildlife sanctuaries, especially for aquatic fauna.
j) The issue of boundaries should be considered. Currently International borders are artificial and arbitrary.

3.8.4. Opportunities

3.8.4.1 The Tourism Master Plan for Western Kenya

The Kenya Tourism Trust Fund (TTF) funds the 15-year Western Kenya Tourism plan. The Master plan acknowledges that of the 230 classified hotels only 20 are in western Kenya. In addition only 9% of the local population visit the national parks and reserves in the region. The document has identitied about 30 tourism circuits within the region. Within these circuits, infrastructure facilities will be upgraded. Some 17 circuits identified are in Nyanza the rest in western Province. The main focus will be the Lake Victoria, which is the world's second largest freshwater mass. The International Tourism Consultant Hitesh Metha and the Lake Basin Development Authority will implement the plan. Some of the activities to be promoted include horse riding in Mt Elgon. Community participation will be promoted and thus form a key element in the process for its success to be realized.

According to the United Nations Convention on Biological Diversity, which Kenya ratified in 1992, wildlife are traditionally regarded as wildlife are an important component of biodiversity. The continued existence of humanity on the planet and the elimination of global poverty depend on recognizing the natural environment, or biodiversity, as the foundation of a sound economy. It is only possible to enjoy economic prosperity now and in the future if a healthy environment is maintained. From the perspective of sustainable use, wildlife is a renewable resource that provides many benefits and socioeconomic advantages. Canadians have much to gain by treating wildlife and wildlife habitat as the precious resources they are and managing them in such a way that future generations will receive their full benefits in perpetuity.

3.8.4.2 Management of wildlife habitats

Transboundary issues with regard to the national parks and game reserves include; curbing illegal activities, tourism development, research and monitoring, capacity building, animal-human conflict, population increase, funding of parks and reserves administration, insecurity, poor management and tourism infrastructure.

3.8.5 Benefits of co-operation in managing shared ecosystem

a) Considerable benefits can accrue to different stakeholders from efforts to address ecosystem-degrading activities at cross-borders sites.
b) Cooperation in the management of cross-border ecosystems has potential to re-establish key ecological functions that may have been disrupted by international borders.
c) The formation of transboudary conservation areas increases the amount of land available for biodiversity and re-establishes seasonal migration routes for migratory animal species.
d) Cross-border biodiversity management increases opportunities for expanded ecotourism by diffusing tourist concentrations and reducing the potential for localized overcrowding and environmental degradation. It may lead to aggregate increase in the total number of regional tourists through multinational destinations.
e) Cross-border ecosystem based activities such as joint technical meetings, research, monitoring and training promote staff morale, transfer of expertise, conservation technologies and information sharing. This increases prospects for the development of compatible policies, management plans, strategies and conservation priorities.
f) Benefits are diversified where central authorities provide policy support, guidance and co-ordination in addition to concentration of cross-border management resources at local, site level. Build support for transboundary effort into broader national planning frameworks.
g) Cross-border communities have a common historical heritage and a lot of indigenous knowledge that can be used in the conservation of cross-border ecosystems.
h) Linkages between NGO's and Government extension departments through regular meetings, working with the same community groups and through memoranda of understanding improve transboundary natural resource management.

3.8.6 Outstanding transboundary issues

i) Compatible community-based natural resources management activities.
ii) Compatible site management plans for shared ecosystem.
iii) Trans-border movement of persons and livestock
iv) Enlargement of local cross-border trade activities for local communities.
v) Regulated livestock movements and joint livestock diseases control.
vi) Joint patrol programmes and compatible law enforcement procedures.
vii) Facilitation of technical and scientific research and mutual assistance rather than legal obligations.

viii) Financing of joint programmes and activities with emphasis on reducing transaction costs.
ix) Capacity building, especially at the district and lower levels of local government to manage complex and integrated conservation and development programmes.
x) Sensitivity to the interest of resource dependent communities etc.

3.9. Forestry Resources

3.9.1. Status of forestry resouces

3.9.1. 1. Natural forests within the lake basin

The Lake Victoria basin has about 460 000 ha of gazetted forests (i.e. plantations, natural forests) which is distributed as follows; Mt Elgon (73 000), Cherangani Hills (53 000), Kakamega Forest (23 000), Nandi Forest (30 000), Tindiret Mau (210 000), IIkerin – Lolgorian (60 000) and Gwassi Hills (12 000). Other smaller forests zones include; Lambwe valley forest, Kodera forest. The main forest cover include; indigenous and exotic species. The most common indigenous tree species are 'Mvule' 'Markhamia' ('*Siala')* and *Olwa*

3.9.1. 2. Industrial plantation development

These are mainly forest plantations of faster growing trees for wood production from the countrys indigenous forests for industrial and wood demand. The main species include *Cypress lusitanica, Pinus patula, Eucalyptus* spp. *(Eucalyptus grandis, Eucayptus urophylla, Eucalyptus camaldulensis* and *Eucalyptus tereticornis).*

3.9.1.3. Farm forestry

Farm forestry consists of trees planted outside the gazetted forests. Currently over 40 % of the woody biomass outside closed canopy indeginous forests is in the farmlands. Most of the trees planted in farming systems are mainly exotic species such as *Gravellia robusta*, *Pinus, Cypress* and *Eucalyptus* spp. *(Eucalyptus grandis, Eucayptus urophylla, Eucalyptus camaldulensis* and *Eucalyptus tereticornis).* Due to small sizes of land within the basin, (0.6 ha in Kisii and 2.2 ha in Kisumu area), the emphasis is to plant agroforestry trees to improve the tree cover in the farming systems. These agroforestry trees consist of *Tithonia diversifolia, Lantana camara, Tephrosia* spp. *Clotalaria* sp., *Sesbania sesban* and *Calliandra* sp. In the recent past there is renewed interest in the use of Bamboo (*Arundinaria alpina)*, as an economic product and for treatment of wastewater. Bamboo rhizomes are effective at holding topsoil on steep slopes to combat erosion. Some species of bamboo grow long straight culms that can be sustainably harvested and used as wind breaks. Bamboo is also a valuable source of firewood, because of its high calorific content and fast growth. Bamboo can also be processed for biogas and charcoal production. One of bamboo's great strengths is its prolific growth with estimates of yield of up to 20,000 culms of 12 m-high plants per hectare each year

According the Kenya Forest Working Group working together with the Government Departments of Resource Surveys and Remote Sensing DRSRS with technical inputs from Christian Lambrechts of UNEP (Daily Nation 19th December, 2004), between the years 2000 to 2003, some 7,084 hectares of Mau forest, which is considered as the water tower of Lake Victoria, were destroyed. In the Lake Victoria

basin the group considered Mau forest, Mt. Elgon and Cherangani Hills. According to the report, 35 % of area cleared lies within Narok and is under indigenous cover. In Mt Elgon, the area around Trans Nzoia District shows a loss of 1,029 hectares of indigenous forest. The least affected areas are in Cherangani area where only 174.3 hectares have been deforested. It should be noted that the area deforested includes the legal sections of the forest where mature trees are felled for timber.

The forest Stations shown on the Tables 3.29, 3.30 and 3.31 were obtained from the survey of Kenya toposheets [They may not exactly represent the situation on the ground where the changes occurred after production of the maps].

Table 3.29 Areas of significant change in the Mau Complex Forest (2000 – 2003)

Site No.	Forest	Constituency	Nearest Forest Stations	District	Area Affected (ha)	Forest Type	Change Type
1	Maasai Mau	Narok North	Oleguruone	Narok	195.15	Indigenous	Deforestation
2	Maasai Mau	Narok south	Oleguruone	Narok	2291.19	Indigenous	Deforestation
3	SW Mau	Kuresoi	Oleguruone	Nakuru	190.49	Plantation	Deforestation
4	SW Mau	Kuresoi	Kerisoi	Nakuru	167.38	Indigenous/ plantation	Deforestation
5	SW Mau / W Mau	Kuresoi / Molo	Kerisoi	Nakuru	42.15	Indigenous	Deforestation
6	Eastern Mau	Kuresoi	Baraget	Nakuru	1971.81	Indigenous	Deforestation
7	SW Mau	Kuresoi	Kerisoi	Nakuru	46.34	Indigenous	Deforestation
8	W Mau	Kuresoi	Kerisoi	Nakuru	14.06	Indigenous	Deforestation
9	SW Mau	Kuresoi	Kerisoi	Nakuru	15.97	Indigenous	Deforestation
10	Eastern Mau	Molo	Mariashoni	Nakuru	201.03	Indigenous	Deforestation
11	Eastern Mau	Molo	Mariashoni	Nakuru	182.80	Indigenous	Deforestation
12	West Molo	Kuresoi	Molo	Nakuru	145.97	Indigenous	Deforestation
13	Mt Londiani	Eldama Ravine/ Molo	Molo	Nakuru	331.85	Indigenous	Deforestation
14	Kilombe hill	Eldama Ravine	Molo	Koibatek	64.55	Indigenous	Deforestation
15	Northern Tinderet	Eldoret South	Serengoni	Uasin Gishu	35.15	Indigenous	Deforestation
16	Northern Tinderet	Eldoret South	Serengoni	Uasin Gishu	287.08	Indigenous	Deforestation
17	Northern Tinderet	Eldoret South	Senghalo	Uasin Gishu	732.35	Indigenous	Deforestation
18	Nabkoi	Eldoret East	Nabkoi	Uasin Gishu	120.49	Indigenous	Deforestation
19	Metkei	Keiyo South	Nabkoi	Keiyo	48.43	Indigenous	Deforestation
Total					**7084.24**		

Table 3.30 Areas of significant changes in Mt Elgon Forest (2002 – 2003)

Site No.	Area Constituency	Nearest Forest Station	District	Area Affected (ha)	Forest Type	Change Type
1	Mt. Elgon	Kaboywan	Mt. Elgon	471.8	Plantation	Regeneration
2	Kwanza	Kimothon	Trans-Nzoia	1029.5	Indigenous	Deforestation
3	Kwanza	Kiptogot	Trans-Nzoia	573.1	Plantation	Regeneration
Total				**1874.4**		

Three sites showed significant changes between 2000 and 2003. As there was some cloud cover in the 2003 satellite image, it could be that some sites affected by significant changes could not be detected.

Table 3.31 Areas of significant change in the Cherengani Forest (2002 – 2003)

Site No.	Area Constituency	Nearest Forest Station	District	Area Affected (ha)	Forest Type	Change Type
1	Marakwet East	Chesoi	Marakwet	17.33	Indigenous	Deforestation
2	Marakwet East	Chesoi	Marakwet	34.59	Indigenous	Deforestation
3	Sigor	Chesoi	West Pokot	100.79	Indigenous	Deforestation
Total				152.71		

The results in Table 3.31 show that about 153 hectares in the Cherengani Forest Reserve have been deforested between 2002 and 2003. It should be noted that there are large areas deforested prior to 2000. It should be noted that the change type “Deforestation” in Plantation might be as a result of legal harvesting of mature trees.

3.9.2. Social and economic values of forests

Forests contribute immensely to the basin’s economy by providing wood and non-wood forest products for commercial and domestic use. For instance, they support the pulp and paper industries, sawmills, the building and construction industry, charcoal production, firewood, transmission posts for telephone lines and woodcarving. They also facilitate income-generating activities such as beekeeping by providing an anchor for beehives. Forests are a wildlife sanctuary, harbouring a host of animals, birds and insects all of which are tourist attractions. Some tree and plant species are important as medicine or food. Specific areas are gazetted as protected forest areas; however, the acreage is diminishing as more land is taken up for settlement and cultivation. The forestry resources may be categorised according

to the user industry. Tables 3.30 and 3.31 depict the changes in the forest cover in the main water towers of Lake Victoria.

3.9.2.1. Wood based industries and uses

a) Pulp and paper industry

The Pan African Paper Mill (PANPAPER) is the only pulp and paper mill in Kenya. It consumes about 500,000 cubic meters of round wood to produce 120,000 tons of paper annually. The company provides direct and indirect employment to 30,000 people and contributes 7 billion shillings annually to the economy (World Bank / PROFOR, 2004).

b) Saw milling and plywood production

Before the ban on harvesting of timber from gazetted forests in 1999, there were licensed saw millers and plywood mills operating in some of gazetted forests in the lake basin.

c) Wood fuel, firewood and charcoal

It is estimated that seventy percent of Kenyans use wood fuel either as firewood or charcoal (UNEP, 2004)). This percentage could be higher in the lake basin, owing to the rural orientation of most households.

d) Transmission and construction poles

The national demand for transmission posts and construction poles is expected to grow from 485,200 to 1.18 million and from 7.23 million to 110.7 million respectively for the period 2005 – 2020 (Ministry of Environment and Natural Resources, 1994). With the government's current programme to supply electricity to 150,000 households annually, the demand for transmission posts will be higher. The lake basin has an opportunity of producing these timber products to close down demand. Of greater interest is that many farmers now recognise timber production as a viable commercial venture.

e) Wood carving

The wood carving industry supports at least half a million Kenyans directly and indirectly (80,000 carvers supporting 400,000 family members). It realises an export value of Ksh. 1.6 billion annually (The Standard, 2005). Some of the trees for wood carvings are produced in the lake basin, particularly in the indigenous forest.

f) Non-wood forest products and services

In the lake basin, the non-wood forest products of economic value include medicinal herbs, fodder, exudates, honey, beeswax, fibre and essential oils among others. Seventy percent (70%) of the production of non-wood forest products is from natural ecosystems. The trade in these products generates about Ksh. 3.2 billion to the national economy. There is an increasing interest in eco-tourism, where the forest cover is itself the attraction.

g) Wildlife sanctuary

The lake basin forests are a reservoir of biological diversity, for example, Kakamega and Mau Forests. This diversity is characterised by large animals, birds, butterflies,

and woody plant species. For instance, Kakamega forest has important biological resources (flora, fauna and avifauna) as follows; 350 plant species, 367 bird species, 40 snake species, 400 species of butterflies, 7 primate species endemic to the forest (10-20 % of the animals only available here, the primates consist- Blue monkeys, Red tailed monkeys, De brazza monkeys, Black and white Columbus, Olive baboons, Velvet monkeys and Pottos

Wildlife is a prime motivation for most tourists visiting the country.[4] Tourism generates a third of the country's foreign exchange (KWS 1995) and 10% of total employment (John *et al*, 1998). Thus, the lake basin can play an important role in developing the tourism industry through its natural forests.

h) Herbal medicine

It is estimated that 37% Kenyans rely solely on herbal medicines (*The Standard*, 2004). The lake basin is recognised as an indigenous source of many herbal plants, particularly in the protected natural forests such as Kakemega Forest. *Prunus Africana*, Mwarubaini Morenga (*Moringa oleifera*) and Mukobero (*Mondia whytei*) for the treatment of prostate cancer treatment, Water purification and aphrodisiac

i) Honey and beeswax

Forests are an important source of natural honey. Kenya has been producing about 4,500 tons of honey and 280 tons of beeswax annually both of which are valued at Kshs. 46.6 million and shs.1.8 million respectively. Commercial honey production is being encouraged as an alternative source of income in rural Kenya, including the lake basin. For instance, in Kakamega Card Kenya has embarked on commercial production of honey. The NGO produces 1 tonne of honey every 2 months or 6 tonnes per year. Most of the honey is taken to honeycare.

Thus, forests support and perpetuate vital economic activities. They also provide for livelihoods through formal and informal employment. It is important that the government invests more in the forestry sector in the basin in order to reap more economic benefits. Adequate resources will assist the sector realize its development requirements. These include the need to; develop and maintain proper management mechanisms for forest resources, increase forest cover and consequently revitalize forest dependent enterprises such as saw milling and plywood manufacturing industries.

3.9.3. Threats to forest resources

3.9.3.1 Agriculture encroachment especially for tea plantantions

In the recent past the local authorities have allocated forest lands for settlement and farming. A substantial forest land from the Kakamega forest was allocated and converted to tea estates.

3.9.3.2 Demand for fuel

Most of the forests are destroyed to make charcoal and firewood. The harvesting of forests for charcoal is carried out using crude technologies that contribute enomourse waste.

3.9.3.3 Forest fires

Forest fires destroys the soil, trees and ecosystem

3.9.3.4 Pests and diseases in forest trees

The main diseases affecting trees are;

- *Lebtocybe invasa*- or the blue gum chalcid of *Eucalyptus*
- Pine wooly alphid, Pine needle alphid, Dothistroma needle blight all affecting mainly the *Pinus* species.
- Armillaria root rot
- *Botryosphaeria canker*
- Black blister caused by a fungus *Trichosporium vesiculosum*- attacking the *Casaurina equisetifolia*

3.9.4. Opportunities

3.9.4.1 Integrated pest management

- Use of aphid biological control agent *Pauesia juniperorum* for the control of Cypress trees pest.

3.9.4.2 Control of forest destruction

One of the most effective ways to halt forest destruction is through demarcation of forest boundaries. Most of the destruction occurs in forests, which are protected by the local authority forests. In such forests proper demarcation is required to halt further destruction. The government should ensure that there is no illegal encroachment of forestland. Particularly the court order of 19th April 2002 barring any alteration of forest boundaries in forests excised in 2001

3.9.4.3 Alternative livelihoods

Activites that can reduce pressure on the forests are butterfly farming, ecotourism, energy efficient technologies, honey production, zero grazing and snake farming.

3.10. Energy resources

The development of the energy sector within the lake basin is fully dependent on the national situation and increasingly, the situation and energy development strategies in the East African region and in Africa as a whole. Kenya's energy policy emphasizes the need for its availability and accessibility at cost-effective prices, and in support of sustainable socio-economic development while protecting and conserving the environment. However, the energy potential in Kenya, and more so in the Lake Victoria basin, is seriously under-exploited. This is similar with the situation in the rest of Africa where less than 4% of the vast hydro-power potential, estimated at 300 gigawatts and even less of its geothermal, solar, wind or biogas potential are being harnessed (Veit *et al.* 1998).

The main sources of energy in Kenya are wood fuel, electricity and oil. Nationally, wood fuel accounts for 70%, while oil and electricity constitute 20% and 9% of Kenya's energy consumption respectively. Wood fuel is consumed mainly as

charcoal in the urban areas or directly as fuel wood in rural areas. Despite Government restrictions, charcoal continues to be harvested from trust lands and gazetted forests, representing an annual business worth KSh 17 billion. The total charcoal consumption in Kenya is about 2.4 million tonnes (or 67 million 36-kg bags), accounting for about 47 per cent of the national energy consumption or 82 per cent in towns and 34 per cent in rural areas. Despite its importance, woodfuel sector has received far less attention and resource allocation than electiricity development. It is therefore important that more attention should be directed at the development of wood fuel, since other sources of energy are unreliable and expensive.

Electricity has been receiving most attention in resource allocation for development and expansion. Generation of electricity though has become expensive due to; ineffective management of power purchase agreements, leading to extremely high tariffs of privately generated power; inequitable distribution of operating costs; weak and inefficient utility management; a bloated work force in the Kenya Power and Lighting Company Ltd, past politicisation of the sector management; wasteful and a cost-ineffective procurement; failure to invest in system reinforcement and poor maintenance of power distribution infrastructure; lack of commitment to reforms and integrity; and governance related issues.

In the Lake Victoria basin, hydro-power generation is limited but the potential is very high (the basin has the potential to generate 563 megawatts (MW) of hydropower as follows; Nzoia river, 159; Yala, 114; Nyando, 14; Sondu Miriu, 249 and Kuja Migori, 27 MW). The current production will expand with the full implementation of the Sondu-Miriu Hydro-power project which is estimated to add about 60 MW initially to the national grid . To reduce costs, some companies in the lake basin have started generating their own electricity. For example, Mumias Company is generating electricity mainly for its own use while some goes to the national grid. Dominion Farms Limited in Yala Swamp has also started producing electricity for its internal use. It is estimated that about 26.6 MW will be produced by Dominion Groups of companies using rice husks. Some tea factories in Nyamira and Kericho districts are also on the verge of generating electricity.

In 2004, Kenyan industries consumed an estimated 514 million tonnes of petroleum products, representing about 20% of the total commercial energy consumed in the country. The main problem affecting this sector is the high cost of petroleum products due to inefficiency of Kenya Petroleum Refineries Limited (KPRL), which is passed on to consumers. A study done by the Kenya Institute for Public Policy Research and Analysis (KIPPRA) recommended reforms, particularly to eliminate taxes on kerosene and cooking gas. It anticipated that zero-rating will increase the consumption of gas and paraffin, hence, reduce the utilization of woodfuel and other energy sources.

Other potential renewable energy sources in the Lake Victoria basin such as solar, geothermal, natural gas, wave and wind energy are not significantly developed. Wind power is used mainly to pump water in a few parts of the basin and to propel sail boats in the lake. Hot springs are present in parts of the basin, but these have not been exploited for geothermal energy. Similarly, conversion of solar power to electric energy is least exploited.

The Development of energy sector in the East African region has attracted international investors. Sweden intends to invest in the power sector in East and Southern Africa with the objective of sharing knowledge on ways to avoid energy shortages in future (particularly in Tanzania and East Africa as a whole) and scaling up power generation activities in the region. The Nile basin countries intend to develop and promote a regional power market. They will develop frameworks and agreements on power trade and also forecast demand per country and the Nile basin as a whole. Currently accessibility to power is only limited to 10 per cent of the 300 million people living within the Nile basin. The main focus will be to identify hydropower generation and transmission projects but with a focus on interconnectivity among countries. This will be implemented through two semi-autonomous investment programmes, namely; the Eastern Nile Subsidiary Action Programme (ENSAP) consisting of Egypt, Ethiopia and Sudan, and; the Nile Equatorial Lakes Subsidiary Action Programme (NELSAP), which includes Burundi, Congo, Egypt, Kenya, Rwanda, Sudan, Tanzania and Uganda.

3.11. Mineral resources

3.11.1. The Status of Mineral Resources

Recent statistics show that mining contributes about 2% of the national Gross Domestic Product. This estimation however ignores the contribution of mining in the building and construction industry. The Lake basin region of Kenya has probably the largest share of cratonic rocks in Kenya. These rocks are similar to rocks in Tanzania and Uganda in which some major mineral deposits have been discovered. The main minerals in the basin are gold, copper, base metals, rare earth elements, Kisii soapstone, limestone (carbonate), phosphate, sulfur, Wollastonite and nephelinite, manganese, tin, kaolin, clay, flourspar, iron ore, graphite, sheltie, diatomaceous soil, and building material (granite, brick clay, sand, tuffs, murrum and material for ballast). Kisii is the sole producer of soapstone in the world.

The main players in the mining industry in the lake basin are;

a) Afri-Ore Company which is doing exploration in the former San Martin license area and covering Nyanza and Western provinces. The company is currently doing drill sampling.
b) Sinai Company which is undertaking exploration in the Mid–Migori license area. It is also drilling in the Sebum – Lolgorien area
c) Homa Lime Company Ltd. which is mining limestone and production of lime and feedstock in the area around Koru.

The artisanal miners need to be organized into cooperatives for easy management and strengthening. One community based organization in Migori District called the Lakeside Mining Co-operative Society, aims at ensuring that local miners benefit from mining through investment in development projects. The group is based at Mikei center in Migori District. In the case of carvings out of the Kisii soapstone, Co-operatives too have been formed to help in marketing products abroad, but most of them have failed due to misappropriation of funds, resulting into discontent by the members. The Kisii Soapstone Carvers Society, based in Tabaka in Kisii District, is

owed huge amounts of money by debtors' abroad who imported the artwork on credit.

3.11.2 Socioeconomic Importance of mineral resources

Gold production form artisanal mining has however continued, providing livelihood to a large number of families. Women and children are often employed in the process in order to increase family income. Another major artisanal activity in the region is related to the extraction of building material. Granite, brick clay, sand, tuffs, murrum and material for ballast are exploited by artisans for local consumption, albeit using hard labour and flouting most environmental safeguards.

3.11.3 Threats to mineral resources exploitation

a. Limited access to capital and knowhow - improper equipment, product quality standards
b. Exploitation by the middlemen
c. Lack of organized groups and cooperative societies
d. Use of mercury in the mining of gold: methyl mercury (MeHg), is a potent neurotoxic chemical which, is harmful to human health and biota.
e. Crude processing mechanisms and lack of value addition

3.11.4. Opportunities in the mining sector

The Government, through the Ministry of Cooperatives, plans to strengthen cooperatives in this sector and assist in debt recovery (Daily Nation 14th May 2006). In most cases, the minerals are sold unprocessed hence, there is need to consider value addition. The artisanal miners could invest in mineral resource processing plants and thus increase the incomes.

3.12. Agricultural sector

3.12.1. Crop production

3.12.1.1. Status of crop production in the lake basin

Agriculture within the Lake Victoria basin involves culture of crops under different agro-ecological zones. Most crops that traditionally were grown purely for subsistence are now sold out after harvest, making it difficult to clearly distinguish between 'food crops' and 'cash crops'. Those traditionally classified as food crops include; maize, beans, rice, cassava, sweet potato, irish potato, sorghum, wheat, millet, banana, pineapples, groundnuts, sim sim, cowpeas, greengrams, soyabeans, tomato and a wide variety of indigenous and exotic fruits, vegetables and other horticultural crops. The main cash crops are sugar cane, tea, coffee, tobacco, sunflower, cotton and pyrethrum. Some of these crops, particularly tea, coffee and horticultural crops, are exported (Table 3.32). Table 3.33 shows the proportional area for each of the major crops planted in the Lake catchment.

Table 3.32 Comparative export earnings of main crops

Sector	Export (in Ksh. Billion)
Tea	42
Coffee	10
Horticulture	46
Tourism	49
Fish	8
Manufacturing	71
Total	**226**

A significant proportion of the area under tea and coffee is located in the headwaters of streams feeding Lake Victoria. Cane and rice are also cultivated close to the lake in areas that were once wetlands. To ensure high levels of production, inorganic fertilizers are used extensively for tea, coffee, sugar and rice production (MOA 2006).

Table 3.33 Agricultural land use in the Lake Victoria catchment (2004)

CROP	AREA (ha)	%
Maize	550000	48.2
Beans	200000	17.5
Sugar	110000	9.6
Sorghum	60000	5.2
Cassava	40000	3.5
Bananas	35000	3.0
Tea	30000	2.6
Cotton	30000	2.6
Coffee	25000	2.2
Millet	25000	2.2
Sweet Potatoes	20000	1.7
Others	15000	1.3
TOTAL	1140000	100

Source: LVEMP Synthesis Report (2005)

The agro-ecological zones (AEZ) within the southern part of lake basin, covering a total of 11 districts of Kisumu, Kisii, Nyamira, Kericho, Bomet, Transmara, Migori, Kuria, Homa bay, Suba and Gucha, are given in Tables 3.34 (from Njue *et al.*, 1997). Agricultural research in these districts is done by KARI Kisii Regional Research

Centre. Table 3.34 gives the area and crops and livestock under each AEZ, while table 3.35 gives details of the altitude and temperature defining the agro-ecological zones. Table 3.36 gives further details of the geo-climatic conditions of the agro-ecological zones of these districts, in particular humidity and rainfall.

Table 3.34 Major agro-ecological zones (AEZ) of the southern districts of the Lake Victoria basin

AEZ	Districts	Area (km^2)	% of total	Major crops and livestock
LH_{1-2}	Kisii, Nyamira, Kericho, Bomet	2659	23	Maize, beans, bananas, tea, horticultural crops. Local and improved cattle, sheep, goats and poultry.
UM_1	Kisii, Nyamira, Kisumu	1369	11	Tea, coffee, bananas, maize, beans, horticultural crops. Local and improved cattle, sheep, goats and indigenous poultry.
UM_{2-4}	Transmara, Bomet, Kericho, Kisumu	1333	11	Maize, beans, finger millet, horticultural crops. Local and improved cattle, sheep, goats and indigenous poultry.
LM_{1-5}	Migori, Homa Bay, Kuria, Kisumu	5933	52	Maize, beans, sorghum, cotton, cassava, sweet potato, ground nuts, cowpeas and horticultural crops. Mainly Local and improved cattle, sheep, goats and indigenous poultry.

Adopted from Njue *et al*. (1997); Jaetzold & Schimdt (1982, 1983)

Table 3.35 Altitude and temperature defining agro-ecological zones (by Jaetzold & Schimdt, 1983)

Temperature/Elevation belts			
Code	Name	Altitude (m. asl)	Temperature range (C))
TA	Tropical Alpine	> 2800	Annual average 2 – 10
UH	Upper Highland	2350 – 2800	Annual average 10 – 15; Average seasonal night frosts
LH	Lower Highland	2000 – 2350	Annual average 15 – 18; Average min. 8 – 11
UM	Upper Midland	1500 - 2000	Annual average 18 – 21; Average min. 11 – 14
LM	Lower Midland	1000 – 1500	Annual average 21 – 24; Average min. >14
IL	Inner Lowland	750 - 1000	Annual average >24; Average Max. > 31

Table 3.36 Humidity and rainfall in the zones

Approximate Equivalent Humidity/Rainfall belts				
Code	Name	r/E_0	Annual rainfall (mm)	60 % reliable growing period (days/year)

1	Humid	>0.80	>1400	270 – 330
2	Sub-humid	0.65 – 0.80	1200 – 1600	240 – 310
3	Semi-humid	0.50 – 0.65	1000 – 1300	210 – 270
4	Transitional	0.40 – 0.50	900 – 1200	150 – 240
4	Semi-Arid	0.25 – 0.40	700 – 1000	90 – 150
5	Arid	0.15 – 0.25	500 - 800	< 100

Adopted from Njue *et al*. (1997); Jaetzold & Schimdt (1983)

3.12.1.2. Socioeconomic Importance of the sector

Agriculture sector in Kenya is the base for economic development, contributing 24 per cent of the Gross Domestic Product (GDP). In addition it also, provides employment to over 75 per cent of the population particularly those living in the rural areas and contributes over 70% of raw materials for agro-processing and 45% of government revenues. It is also a major foreign exchange earner through exports of tea, coffee and horticulture (Table 3.32). The sector's direct and indirect contribution to the GDP is approximately 50%, making it a key player to national development and poverty reduction.

3.12.1.3 Threats within the sector

Agriculture has been experiencing low and declining productivity in terms of export earnings, employment creation, food security and household farm incomes. The reasons for agricultural decline include; Poor governance of key agricultural institutions, particularly the cooperative sector, lack of a comprehensive legal framework to guide formulation of consistent policies, institutional failure due to lack of capacity by the private sector to take over the functions previously performed by the state after liberalization, lack of markets and weak marketing systems, poor access to farm credit, high cost of farm inputs, insecurity in certain parts of the country, and taxation of farmers through local authority cess and other levies, high prevalence of HIV/AIDS affecting agricultural work force, low level of public funding, inefficient use of public resources resulting in inadequate and inefficient infrastructure reulting into high cost of production, and inappropriate technology that is unresponsive to variations in agri-ecological zones and inadequate funding for research and extension services.

The major issues on production within the sector include: low production due to unpredictable weather patterns, low fertility of the soils, non-adoption of modern technology, high incidences of crop pests and high population pressure on the land due to diminishing land parcels as they get subdivided due to inheritance. Cross-border trade of agricultural products also affects agricultural production in Kenya.

The cost of production is low across the borders as a result the prices of the commodities are low compared to the same products that are produced within the country. This causes a glut in the market and lead to lowering of the value of Kenya's produce making the farmers earn less. In addition the grain trade across the national borders also contribute to the spread of pests and livestock diseases.The Law presently restricts movement of plants, however, pests are still spread because of lack of enforcement of the existing laws.

The Department of Agriculture should enhance environmental conservation measures along with farming practices in the form of soil conservation, riverbank protection and conservation, water harvesting and management, and agro-forestry practices. There are adequate policies existing on land use and environment protection within the sector, however, the major constraint in enforcing these environment regulations is adherence by farmers to the good practices. Possible interventions within the sector would involve strict enforcement of these policies, sensitisation of policies and intersectoral coordination particularly with the administration.

In order to institute reforms in the agricultural sector, the government intends to institute legal and institutional reforms, enhance research and extension services; improve access to credit, rehabilitate irrigation schemes, encourage diversification of enterprises and crop uses; liberalise domestic market for pyrethrum, improve cooperative development, improve value addition to exports and establish modalities for effective and sustainable Guaranteed Minimum Return.

3.12.1.4 Crop diseases

There are a number of crop diseases in the Lake Victoria catchment. The high temperatures, humidity and rainfall provide ideal conditions for plant diseases. Furthermore, the unrestricted movements of farm products, seeds and other planting materials across the country means that diseases can be easily transferred across agro-ecological zones. There is a legal framework detailing the procedures for importing and exporting plants and plant materials so as to limit cross-border spread of pests and diseases. However, informal, illegal and uncontrolled trade takes place at several points along the border, making it difficult to restrict imports of plant materials between the riparian states. The diseases are mostly fungal, although there are also viral and bacterial diseases. Some of the most important crop diseases in the Lake Victoria basin are; Cassava mosaic virus, Wheat rust, Cofee berry disease, Maize leaf rust, Streak rust, Bean mosaic virus, Bean rust, Sugarcane mosaic virus etc.

3.12.1.5 Crop pests

Crop pests are mainly insects but also include rodents and birds that may cause serious losses in crops. Among the larger pests are squirrels, rats, mice and moles, which can cause a lot of damage to root crops. Generally, these pests can be controlled by trapping, digging out their burrows and keeping vegetation along the field edges short. The pests for specific crops and fruits are presented in Tables 3.37 and 3.38 respectively. The most effective way to control crop pests is by integrated pest management (IPM) which, involves a combination various pest control methods such as biological, mechanical, chemical, good farming practices e.g. early planting, crop rotation, synchronised planting and harvesting season, etc.

Table 3.37 Crop pests

Crop	Common Pests
Maize	Maize Stem borer (*Buseolla* spp.). Maize Planthopper (*Peregrinus maidis*), Maize aphid (*Ropalosiphum maidis*), Maize weevil (*Sitophilus zeamais*), Lesser stalk borer (*Elasmopalus spp.*), Bollworm (*Helicoverpa zea*), Armyworm (*Spodoptera frugiperda*); Birds (e.g. *Quelea quelea, weaver bird)*; Rats (*Rattus rattus*);
Rice	Spider mite (*Schizotetranychus spp.*), Rice stink bug (*Oebalus poecilus*), Leafhopper (*Hortensia similis*), Rice water weevil (*Lissorhoptrus oryzophilus*), Rice webworm (*Syngamia spp.*), Armyworm (*Spodoptera frugiperda*); Birds (e.g. *Quelea quelea, weaver bird*); Rats (*Rattus rattus*).
Sorghum	Stink bug (*Nezara viridula*), Green bug (*Schizaphis graminum*), Maize aphid (*Ropalosiphum maidis*), Rusty plum aphid (*Hysteroneura setariae*), Bollworm (*Helicoverpa zea),* Armyworm (*Spodoptera frugiperda*), Sorghum midge (*Contarinia sorghicola*), Sorghum aphid (*Melanaphis sacchari*); Birds (e.g. *Quelea quelea, weaver bird*);
Cassava	Cassava mite (*Mononychellus caribbeanae*), Glovers spider mite (*Tetranychus gloveri*), Cassava lace bug (*Vatiga illudens),* Cassava scale (*Aonidomytilus albus)*, White grubs (*Phyllophaga spp.)*.
Sweet potato	Whitefly (*Aleurotrachelus trachoides)*, White grubs (*Phyllophaga spp.)*, Sweet potato weevil (*Cylus formicarius),* Tortoise beetle (*Metriona flavolineata)*, Red spider mite (*Tetranychus spp.);* Snails Rats (*Rattus rattus*).;
Irish potato	Potato aphid (*Macrosiphum euphorbia)*, Root aphid (*Rhopalosiphum rufiabdominalis),* Green peach aphid (*Myzus persicae),* Potato weevil (*Premnotrypes vorax)*, Potato tuber moth (*Phthorimaea operculella*), Lesser cotton leafworm (*Spodoptera exigua)*.
Onion	Bulb mite (*Rhizoglyphus robini)*, Onion thrips (*Thripa tabaci)*, Lesser cotton leafworm (*Spodoptera exigua)*, Onion leafminer (*Liriomyza trifolii)*.
Tomato	Tomato russet mite (*Aculops lycopersici*), Tobacco budworm (*Heliothis virescens*), Potato aphid (*Macrosiphum euphorbiae)*, Whitefly (*Trialeurodes vaporariorum)*, Sweet potato whitefly (*Bemisia tabaci),* Banded cucumber beetle (*Diabrotica balteata*), Tomato pinworm (*Keiferia lycopersicella),* Lesser cornstalk borer (*Elasmopalpus lignosellus),* Tobacco hornworm (*Manduca sexta*), Tomato fruitworm (*Helicoverpa zea),* Tobacco budworm (*Heliothis virescens)*, Armyworm (*Spodoptera ornithogalli; Spodoptera exigua)*, Onion leafminer (*Liriomyza trifolli)*, Mouse (*Mus musculus*), spider mite (*Tetranychus spp.)*, Stink bug (*Nezara viridula*).
Onion	Bulb mite (*Rhizoglyphus robini)*, Onion thrips (*Thripa tabaci)*, Lesser cotton leafworm (*Spodoptera exigua)*, Onion leafminer (*Liriomyza trifolii)*.
Beans	Spanish slug (*Lehmannia velentiana)*, Spider mite (*Tetranychus urticae)*, Yellow tea mite (*Polyphagotarsonemus latus)*, Common cricket (*Gryllus assimilis*), Stink bug (*Nezara virudala*), Bean leaf hopper (*Empoasca kraemeri*), Legume aphid (*Picturaphis brasiliensis),* Greenhouse whitefly (*Trialeurodes vaporariorum*), Sweet potato whitefly (*Bemisia tabaci)*, Red-horned leaf beetle (*Cerotoma ruficornis*), Banded cucumber beetle (*Diabrotica balteata*), Bean bruchid (*Acanthoscelides obtectus)*, Bean webworm (*Hedylepta indicate*), Bean hesperiid (*Urbanus proteus)*, Granulate cutworm (*Feltia subterranean)*, Onion leaf miner (*Liriomyza trifolii)*.
Cowpeas	Stink bug (*Nezara virudala*), Black legume aphid (*Aphis craccivora)*, Red-horned leaf beetle (*Cerotoma ruficornis*), Banded cucumber beetle (*Diabrotica balteata*), Mung moth (*Maruca testulalis*), Onion leaf miner (*Liriomyza trifolii*), Bean webworm (*Hedylepta indicate*).
Soy beans	Red-horned leaf beetle (*Cerotoma ruficornis*), Banded cucumber beetle (*Diabrotica balteata*), Bean webworm (*Hedylepta indicate*), Stink bug (*Nezara virudala),* Velvet bean caterpillar *(Anticarsia gemmatalis)*.
Pea	Spider mite (*Tetranychus urticae)*, Onion thrips (*Thrips tabaci)*, Onion leaf miner (*Liriomyza trifolii*).
Pigeon pea	Stink bug (*Nezara viridula*), Cotton lace bug (*Corythucha gossypii*), Bean leaf hopper (*Empoasca kraemeri*), Black legume aphid (*Aphis craccivora*), Cottony cushion

	scale (*Icerya purchasi*), Black scale (*Saissetia oleae*), Pea pod borer (*Etiella zinckenella*), Mung moth (*Maruca testulalis*), Cotton bollworm (*Helicoverpa zea*), Tobacco budworm (*Heliothis virescens*), Spine bug (*Umbonia craccicornis*), Onion leaf miner (*Liriomyza trifolii*)
Cabbage	Diamond black moth (*Plutella xylostella*); Mealy cabbage aphid (*Brevicoryne brassicae*); False cabbage aphid (*Lipaphis erysimi*); Green peach aphid (*Myzus persicae*); Cabbage web-worm/beadborer (*Hellula undalis*) and Bagrada bug (*Bagrada* spp.), Cabbage semi-looper (*Trichoplusia ni*), Cabbage budworm (*Hellula phidilealis)*, Cabbage semi-looper (*Trichoplusia ni)*.
Tobacco	Tobacco whitefly (*Bemisia tabaci*); tobacco beetle (*Lasioderma spp.*), Tobacco budworm (*Heliothis virescens*), Stink bug (*Nezara viridula*), Common cricket (*Gryllus assimilis)*, Green peach aphid (*Myzus persicae)*, Lesser cornstalk borer (*Elasmopalpus lignosellus)*, Tobacco hornworm (*Manduca sexta),* Cotton bollworm (*Helicoverpa zea*), Tobacco budworm (*Heliothis virescens)*.
Cotton	Cotton blister mite (*Acalitus gossypii*), Glovers Spider mite (*Tetranychus gloveri*), Cotton aphid (*Aphis gossypii*), Cotton whitefly (*Bermisia tabaci*), Boll weevil (*Anthonomus grandis; Pectinophora gossypiella*), Cotton leaf perforator (*Bucculathrix thurberiella*), Cotton leaf worm (*Alabama argillacea*), Cotton bollworm (*Helicoverpa zea*), Tobacco budworm (*Heliothis virescens*), Lesser cotton leafworm (*Spodoptera exigua*), Cabbage semi-looper (*Trichoplusia ni*), Green peach aphid (*Myzus persicae*).

Table 3.38 Fruit pests

Crop	Pest
Banana	Glovers Spider mite (*Tetranychus gloveri*), Banana thrips (*Frankliniella parvula*), Banana aphid (*Pentalonia nigronervosa*), Citrus mealybug (*Planococcus citri*), Spiralling whitefly (*Aleurodicus dispersus*), Banana weevil (*Cosmopolites sordidus*), Cane weevil (*Metamasius hemipterus*), Rhinocerus beetle (*Strategus oblongus*), Woolly whitefly (*Aleurothrixus floccosus*).
Citrus fruits (Orange, mandarin, lemon etc.)	Citrus rust mite (*Phyllocoptruta oleivora*), bud mite (*Aceria sheldoni*), Citrus spider mite (*Panonychus spp.*), Black citrus aphid (*Toxoptera aurantii*), Green citrus aphid (*Aphis spiraecola*), Green scale (*Coccus viridis*), Brown scale (*Coccus hesperidum*), Black scale (*Saissetia oleae*), Red scale (*Chrysomphalus aonidum*), Citrus mussel scale (*Lepidosaphes beckii*), Glover scale (*Insulaspis gloverii*), Citrus snow scale (*Unaspis citri*), Whitefly (*Dialeurodes citrifolii*), Citrus blackfly (*Aleurocanthus woglumi*), Sugarcane weevil (*Exophthalmus spp*), White grubs (*Phyllophaga spp.*), Spider mite (*Eutetranychus banksi*) etc.
Mango	Star scale (*Vinsonia stellifera*), Trilobite scale (*Pseudaonidia trilobitiformis*), Mango shield scale (*Kilifia mangiferae*), White mango scale (*Aulacaspis tubercularis*), Fruit fly (*Anastrepha obliqua*), Common tree mite (*Nasutitermes costalis*); Rat (*Rattus rattus*).
Guava	Red-banded thrips (*Selenothrips rubrocinctus*), Melon aphid (*Aphis gossypii*), Avocado mealybug (*Nipaecoccus nipae*), Guava mealy scale (*Chloropulvinaria psidii*), Soft green scale (*Coccus viridis*), Wooly whitefly (*Aleurothrixus floccosus*), Fruit fly (*Anastrepha obliqua*), Guava mealy bug (*Ferrisia virgata*).
Avocado	Red-banded thrips (*Selenothrips rubrocinctus*), Pyriform scale (*Protopulvinaria pyriformis*), Mango shield scale (*Kilifia mangiferae*), Wooly whitefly (*Aleurothrixus floccosus*), Avocado mealybug (*Nipaecoccus nipae*); Woodpecker
Pawpaw	Pawpaw scale (*Pseudoparlatoria ostreata*), Fruit fly (*Toxotrypana curvicauda*), Spider mite (*Tetranychus spp*), White peach scale (Pseudaulacaspis pentagona), Coconut scale (*Aspidiotus destructor*).
Pineapple	Mealybug (*Dysmicoccus neobrevipes*), Scale (*Diaspis bromeliae*).
Melon, Cucumber	Red spider mite (*Tetranychus spp.)*, Palm thrips (*Thrips palmi)*, Melon aphid (*Aphis gossypii)*, Melon aphid (*Aphis gossypii*), Melon worm (*Diaphania hyalinata)*, Onion leafminer (*Liriomyza trifolii)*; Rat (*Rattus rattus*).

3.12.1.6. Opportunities in agricultural production

Opportunities in the agricultural sector include loans from the Agricultural Finance Cooperation (AFC), reduced lending rates from the financial institutions e.g. Equity Bank, financial and technical assistance from institutions such as the Kenya Sugar Board and increased and stable market prices for Agricultural produce

3.12.2 Livestock Sector

3.12.2.1 The Status of livestock production

The main type of livestock kept are still the Zebu cattle but this traditional paradigm is rapidly changing; dairy herds of pure and cross breeds are increasing yearly, although the districts in the Rift valley and the old greater Kisii District have significant numbers of cross-breeds and high-producing breeds. There are about 1.5 million cattle within the within the Lake Victoria basin. Most of the cattle kept are local zebu breeds. Although these are disease-resistant they normally have low output as a result of inbreeding, low quality feeds and lack of inputs to cause significant improvement. Grazing is communal and low in feed content, but there are also isolated cases of tethering animals. Dairy cattle are mainly found in the highlands in the basin, while lowlands are characterized by low numbers, with Bondo and Suba districts the worst hit compared to other districts. Beef production is low and mainly based on zebu cattle. Proposals are being made for introduction of Borana and Sahiwal breeds to maintain the same output but reduce the number of animals within the catchment. The policy of castrating local breeds to improve their quality has met opposition from local farmers. The small East African goat, sheep and poultry also play a major economic role. Enterprises associated with livestock such as hides and skins, marketing of raw milk and milk products, egg and meat production for the local market are prevalent. Bee keeping is dominant in the marginal areas and valley bottoms of the high potential areas.

There are a high number of local breeds of goats and sheep within the catchment. They are typically browsers and often destructive to mixed farming practices where shrubs are grown in farms for woodfuel.

Domesticated poultry are kept within the region mostly on free-range. Exotic breeds are kept for egg production and meat production.

3.12.2.2 Issues in provision of dairy services

New technologies are being adopted without evaluating the impacts of such technologies. In any case many farmers are unable to adopt useful technologies due to poverty. There is need to improve vaccination facilities in the Lake Victoria catchment in order to boost livestock production. Dipping facilities should also be improved, as the number of operational dipping facilities is limited. Use of acaricides is not rampant in Nyanza. Cheaper and effective drugs should be made available to farmers. There is also need to change the vaccination strategies. More success in controlling diseases could be achieved if a wider area is targeted, for example, animals in a whole village or location could be vaccinated rather than just targeting the individual farmer reporting a disease outbreak. Vaccinations could also be done

routinely rather than waiting for outbreaks to be reported. In general, technologies that are used in livestock disease control should be more user and environmentally friendly.

3.12.2.3. Socioeconomic Importance of livestock production

The livestock industry comprises mainly of dairy, meat production and hides and skins from cows, sheep, goats and poultry. It is a direct source of food and accounts for 7 percent of GDP. Small-scale producers also dominate the sector. Eighty percent of the milk consumed in the domestic market is produced by small-scale producers and marketed through informal channels. The industry plays a major role on employment and impacts on poverty levels.

Livestock is kept in the region as a form of wealth accumulation and for a fall back when money is needed in special circumstance such as medical or education expenses.

3.12.2.3. Threats to livestock production in the lake basin

3.12.2.3.1. Poor marketing of livestock products

The most common disease to poultry production is the Newcastle whose outbreak has caused many farmers to lose their poultry stock. Poverty is an important hinderance to poultry production in the region.

3.12.2.3.2. Poor policies regarding this sector

To improve this sector the government needs to develop clear policy on milk production, processing and marketing, emphasizing on health and safety standards; promote animal health by reactivating and expanding dipping, breeding and clinical services, including monitoring and control of diseases through stocking of government drugs by animal health technicians; promote dairy goats as an emerging source of milk and other small stock activities such as poultry and bee-keeping; support the development of facilities for milk handling such as collection and cooling centres; encourage the private sector and local authorities to establish small abbatoirs and meat processing facilities; and encourage the establishment of value adding processes.

In order to improve cattle production within the region, there is need to improve the productivity but minimise inbreeding within herds; control stocks in rangeland, provide and maintain watering points. There is also need to improve the Sahiwal breeds to improve production.

3.12.2.4. Environmental implications of livestock production

Due to the high stocking rates in the catchment cattle tracks are sources of soil erosion that, as evidence, can be seen in terms of huge clouds of dust during the dry periods. During the wet seasons these tracks are points of large gullies, for example, Katuk Kodeyo and Bugo in the Nyando and Miriu river catchments.

Concerted efforts should be made to reduce the number of animals within the catchment in order to minimize their environmental impact and at the same time maintain the production levels to prevent shortages. There is also need to boost the

production of high quality yielding breeds to minimise the number of zebus. Cattle production in the region can be improved by keeping cattle out of moist wetland conditions, improve on cattle handling and breeding.

Poverty is also an impeding factor in the adoption of technologies for improved livestock production in the lake catchment, especially on commercial goat-keeping. Credit provision in the region is considered a risky venture and as a result there are no appropriate credit-providers.

There is need to develop feeds in the region, particularly improve the feed quality and feedlots. Effort should also be made to develop proper marketing channels and on value addition to livestock products.

The national policies on livestock production and dairy production are still in draft form.

3.12.2.5 Livestock production issues

The main issues are communal grazing is rampant in many areas making it difficult to improve feed quality; non-controlled grazing (free range type of grazing); too many animals have exceeded the carrying capacity; the cattle tracks are numerous and resulting into gulleys during the rainy season, contributing to soil erosion; there is need to assess potential of hippo grass, *Vossia cuspidata,* in feeding livestock; and proximate analysis to compare the nutritive value of hippo grass with Napier grass.

3.12.2.6 Suggested interventions in the livestock production

i) Improve production systems and thus reduce the number of animals
ii) Use of controlled systems like zero grazing to reduce soil erosion
iii) Selective breeding of the local breeds with the Sahiwals and Boran cattle, though Boran cattle are bigger and require a lot of food

3.12.3. Veterinary services

3.12.3.1 Animal diseases

The major livestock diseases in the basin are; Trypanosomiasis, East Coast Fever, Anaplasmosis, Babeosis, Heartwater, Newcastle disease, Foot and mouth disease, Rift Valley fever, rabies etc. Diseases of livestock within the region, which catch the most attention, are trypanosomiasis and East Coast fever (tickborne). Two projects have been instrumental in controlling trypanosomiasis within the region, namely; Pan African Tick and Environment Control (PATEC) and Farming in Tsetse Controlled areas (FITCA). PATEC is still on going while FITCA ended.

FITCA was based in Bondo and Siaya districts with benefits spreading out to other districts. The main achievement was that the incidences of the diseases were reduced. But the problem aggravated due to drought as the animals had to be moved to other areas for grazing.

PATEC is being financed by IGAD and aims at minimising sleeping sickness in Suba district. It aims at spraying the affected regions until the disease is minimized and then netting material material are used to cover cattle in bomas. The effectiveness

of the programme has not been evaluated, however, the target is to limit trypanososmiasis incidences to about one percent.

3.12.3.1.1. Cattle diseases

The most common critical diseases for cattle in the region are trypanosomiasis and tick-borne diseases. Local breeds of cattle are relatively disease resistant. Most of the exotic breed have been hit hard by this disease and is the main factor responsible for low numbers of cattle within some districts, for example Suba. Table 3.39 gives the incidences of the main cattle diseases by Districts in Nyanza Province.

Tickborne diseases are a menace to dairy cattle production in the region, East Coast fever being the main disease. There are also other tickborne diseases prevalent in the region like Red Water and Digana. The local breeds are resistant to tickborne diseases but cross-breeds are seriously affected. Adopting improved livestock management techniques can control the diseases.

Trypanosomiasis in livestock production (and sleeping sickness or nagana in human beings) is still rampant in Suba, Bondo, Teso and Busia districts. National parks, such as Ruma National park, are major transmission and holding areas for trypanososmiasis since most wildlife are carriers of *trypanosome*. Other diseases in the area include; Liver flukes, hydatid and helminthes, which have been detected in Nyanza province. There is need to control diseases since they lead to wastage in animal production.

3.12.3.1.2. Goat diseases

The bulk of goats within Nyanza province are local breeds that do not get attacked by many diseases.

3.12.3.1.3. Poultry diseases

The major disease for for poultry in the region is Newcastle and this has been a menace to farmers (Table 3.40). No case of avian flu has been reported in Nyanza province.

3.12.3.1.4. Swine diseases

Pig production within the region suffers from marketing problems and they are mainly free-range, making them susceptible to intestinal parasites.

3.12.3.2. Opportunities in livestock production

The opportunities that exist in the livestock production sector include enhanced prices for livestock products, revival of the Kenya Meat Commission and revival of the Kenya Cooperative Creameries (KCC). In order to improve the outputs of local breeds there is need to cross-breed in order to boost milk production from 5 to 6 litres per animal per day. Dairy goat production needs to be developed within the region by bringing exotic species to boost milk production and improve the nutrition requirements for the region.

Table 3.39 Incidences of animal diseases in the Nyanza Province of the Lake Victoria basin

Disease	East Coast Fever			Anaplasmosis			Babesiosis			Heartwater			Trypanosomiasis		
District	**2005**	**2004**	**2003**	**2005**	**2004**	**2003**	**2005**	**2004**	**2003**	**2005**	**2004**	**2003**	**2005**	**2004**	**2003**
Siaya	112	323	410	135	374	974	48	70	98	3	35	86	347	345	565
Homa Bay	223	51	182	245	131	322	60	66	135	50	109	179	446	344	671
Kuria	43	48	45	61	48	64	29	40	28	23	14	-	28	27	-
Migori	347	295	310	511	341	127	108	163	79	204	116	120	543	639	660
Central Kisii	75	79	112	172	273	432	-	19	7	-	2	7	-	-	7
Nyamira	209	156	187	486	337	372	50	20	21	20	13	20	-	1	-
Kisumu	64	84	79	164	222	194	47	55	56	2	34	5	126	125	156
Suba	83	153	177	159	105	148	29	19	57	46	23	24	344	294	582
Rachuonyo	65	95	89	156	176	-	132	275	-	29	123	72	429	419	400
Gucha	125	64	124	152	102	296	27	2	29	40	3	23	-	-	-
Bondo	367	495	464	311	491	360	47	151	161	80	120	42	511	698	755
Nyando	344	278	241	393	275	273	114	85	79	165	75	74	2	5	8
Province	**2,057**	**2,121**	**2,420**	**2,945**	**2,875**	**3,562**	**691**	**965**	**750**	**662**	**667**	**652**	**2776**	**2897**	**3804**

Table 3.40 Incidences of poultry diseases in the Nyanza Province of the Lake Victoria basin

District	2005	2004	2003
Siaya	-	21,300	31,738
Kisumu	21,280	18,640	5,425
Homa-Bay	27,220	28,764	33,540
Kuria	3,900	1,000	3,600
Migori	3,821	2,870	80,000
C/Kisii	-	300	59,500
Nyamira	1,462	2,700	145
Rachuonyo	3,872	11,800	2,236
Suba	1,451	251	983
Gucha	800	700	-
Bondo	21,700	2,400	2,750
Nyando	3,821	3,887	3,665
Province	**92,131**	**94,612**	**223,582**

3.14. Health Status in the Lake Victoria Basin

3.14.1. Background to health status

Lake Victoria basin is an area of potentially high economic output for the region having vast resources, which are neither fully utilized nor exploited in a sustainable manner. A rapidly increasing human population has resulted in increased activities that impact negatively on the health and quality of the life. There are expanded human settlements and urbanization without the accompanying proper planning and improved infrastructure facilities. The lake itself, besides being a source of food, water and recreation, offers important opportunities such as fisheries, transport and communication, water and energy, tourism, agriculture and mining.

The lake basin is an area of mild climate and heavy rainfall. Improper surface and subsurface drainage is a common feature and flooding within the region is a common phenomenon. Urban centers around the lake are responsible for indiscriminate discharge of raw sewage directly into Inflow Rivers and streams and into the lake itself. The unsanitary conditions at landing sites especially due to the small number of toilets leads to high level of feacal contamination of water. This contributes further to the continuously deteriorating health conditions of the region.

Health is a central issue to any socio-economic development of a community. An unhealthy community is an unproductive community due to the weakened capacity to produce goods and services. The general standards of health in the Lake Victoria region are low. A health and demographic surveillance set up within the Lake Victoria basin shows that life expectancy at birth within the surveillance site is 38 years, infant mortality rate 125 per 1000 live births, and under-five mortality rate stood at 227 per 1000 live births (Adazu *et al.* 2005). Such standards of health should be unacceptable. The issue of health and nutrition of communities within the

Lake Victoria region, as in other parts of Africa, is often not adequately addressed in a manner that stimulates formulation of policies and actions. Africa, hosting approximately 11% of the world's population, was estimated to be bearing 24% of the world's burden of disease in 2001 (WHO, 2003). According to the Millennium Development Goals of the United Nations, measured against baseline year 1990, all member states have pledged to undertake programs that will reduce by two thirds the mortality rate among children under five, reduce by three quarters the maternal mortality ratio, halt and begin to reverse the spread of HIV/AIDS halt and begin to reverse the incidence of malaria and other major diseases by the year 2015 (United Nations, 2003). Communities within the Lake Victoria basin currently lack the economic resources to meet these health-related millennium goals.

3.14.2 Health concerns within the Lake Victoria basin

Predominant health issues in the region are linked to vector-borne diseases, unsafe water contaminated by microbial and chemical pollutants and poor disposal of human waste, and food insecurity leading to malnutrition. Emerging and other infectious diseases such as HIV/Aids and related illnesses, T.B, upper respiratory diseases and accidents also heavily burden the region (Table 3.41).

Table 3.41 Common Human Diseases in the Lake Victoria basin

Vector-borne	HIV/AIDS and Related Illnesses	Water-Borne diseases
Malaria	HIV/AIDS	Typhoid
Schistosomiasis	T.B	Cholera
Trypanosomiasis	Upper Respiratory Infections	Amoebiasis
	Meningitis	
	Pneumonia	
	Anaemia	

Some health problems in the region are exacerbated by climatic conditions, whose extremes overwhelm the community's coping capability. Infant mortality rates in the lake region are higher than national averages. In Kenya, while the national level was 74 deaths for every 1000 live births, in the Nyanza province, the ratio was a high 135/1000 (LBDA, 2004). The top ten reported outpatient morbidity in Nyanza province are shown in Tables 3.42 and 3.43.

Table 3.42 Top ten-outpatient morbidity in Nyanza Province

Rank	Disease	Total Reported Cases
1	Malaria	1,327,696
2	Diseases of the Respiratory Tract	506,964
3	Diseases of the Skin (incl. Ulcers)	172,701
4	Diarrhoea	158,855
5	Intestinal worms	89,447
6	Pneumonia	74,391
7	Accidents	69,381
8	Urinary Tract Infections	58,278
9	Rheumatism, Joint Pains	45,657
10	Eye Infections	41,360

Source: Provincial Annual Report 2004. Ministry of Health.

Table 3.43 Outpatient morbidity in Districts in Nyanza with Fishing communities. (--- means no data)

Disease Top 10 Diseases	**Kisumu**	**Nyando**	**Bondo**	**Homa Bay**	**Suba**	**Rachuonyo**	**Migori**
	Ranking of Diseases						
Malaria	1	1	1	1	1	1	1
Diseases of the Respiratory Tract	2	2	2	2	2	2	2
Diseases of the Skin (incl. Ulcers)	3	3	3	4	4	3	3
Diarrhoea	4	4	4	3	3	4	4
Intestinal worms	5	6	5	5	5	5	8
Pneumonia	9	5	7	7	7	6	5
Accidents	6	7	8	---	8	7	
Urinary tract Infections	7	---	6	6	6	8	6
Rheumatism, Joint Pains	8	9	----	----	9	---	10
Eye Infections	10	8	9	8	10	---	---
Ear Infections		10	10	9	---	---	---
Anaemia	---	----	---	10	---	---	---
Diseases of Circulatory system	---	---	---	---	---	9	7
Gonorrhoea	---	---	---	---	---	---	---
Dental disorders	---	---	---	---	---	---	9

Source: Provincial Annual Health Report 2004. Ministry of Health

There is a certain amount of limitation to regional averages of morbidity figures, which is the potential to overlook special communities with unique disease profiles, and consequently the oversight to target such communities with specific control strategies. These rankings tend to bias towards acute illnesses with definite intense diagnostic symptoms. The Provincial list of outpatient morbidity does not highlight some critical issues that are focused within special vulnerable groups, such as infants, school children and pregnant women. It is also important to highlight fishing communities within the Lake Victoria basin as communities requiring special attention because of their exceptionally high water contact and therefore their potentially high exposure to water contact diseases, as well as their recognized vulnerability to HIV/AIDS.

Whereas schistosomiasis is not ranked as an individual problem in the outpatient morbidity levels, there are special groups where almost 100% of the population suffers from the disease (Karanja *et al.* 1997). Despite fishing communities being the hub of the fisheries sector, many are at the margins of national development. Available data suggests that these communities are disproportionately affected by HIV/AIDS, bilharzia, malaria, cholera and other waterborne diseases. A combination of factors including: poor sanitation, poor nutrition, limited access to medical care, daily exposure to contaminated water, low incomes and relative mobility, make fishing communities vulnerable to these diseases.

Most communities around the Lake Victoria are characterised by poor road infrastructure, inadequate health and education facilities and services, as well as poor water and sanitation (Grellier *et al.* 2004, MoLFD/NACC 2004, Tanzarn & Bishop-Sambrook, 2003). In Kenya, an average of 21.7 percent of households in the Lake Victoria basin live at least 8 kilometres away from a health facility (LBDA 2004).

The poor infrastructure and services make it difficult for residents in many parts of the basin to access health services.

3.14.3. Malaria and the population

3.14.3.1. Status and distribution

At least 300 million acute cases of malaria occur worldwide each year, resulting in more than one million deaths annually of which more than 80% are estimated to occur in sub-Saharan Africa, mostly among children under five years old (http://www.globalhealthreporting.org/malaria.asp). Malaria in the Lake Victoria basin is endemic and transmission is intense and affected by climate and geography. It often coincides with the rainy season. Rural communities are the most affected, but urban areas are not spared either. There is a close link between urban malaria and drainage set-ups found within cities due to unplanned development. This creates the potential for an increase in malaria linked to rapid urbanization, especially in the poorly planned and poorly drained slum sectors of the cities and towns. According to 1999 Statistics, malaria constituted approximately 32% of the total outpatient cases in Nyanza and Western provinces in Kenya, followed by upper respiratory tract infections, skin diseases and diarrhea. This picture still holds true for the 2004 statistics (Table 3.42).

3.14.3.2. Trends in malarial attacks

Recently, data from 1982-1998 were analysed across 28 DSS sites, adjusting for the specificity and sensitivity of verbal autopsies that were used to attribute deaths to malaria (Africa Malaria Report 2003). Malaria mortality in under-5s almost doubled in eastern and southern Africa over the period 1990-1998 compared with 1982-1989 (Figure 3.28).

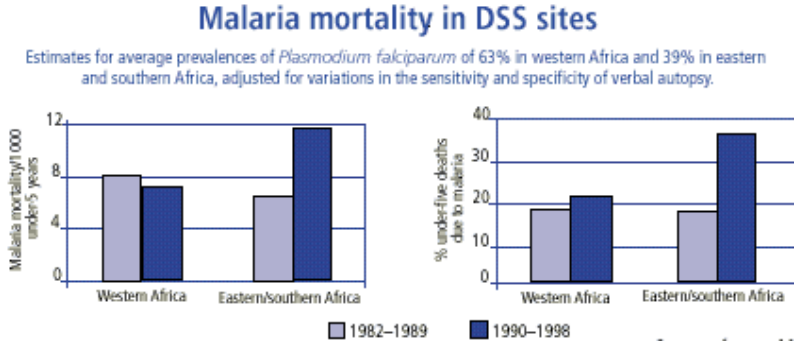


Figure 3.28 Trends in malaria mortality in Africa (Source: *Africa Health Report 2003*)

Some of the important factors that may have contributed to the increasing malaria burden in these African settings include:

1) drug resistance
2) more frequent exposure of non-immune populations
3) emergence of HIV/AIDS
4) climate and environmental change
5) breakdown of control programmes

3.14.3.3. Impacts of malaria within the lake basin.

Malaria kills more people than any other communicable disease except tuberculosis, killing approximately one child every 30 seconds. The most vulnerable groups to malaria in the population are usually children and pregnant women. There are three principal ways in which malaria can contribute to death in young children:

Acute infection, which frequently presents as seizures or coma (cerebral malaria), may kill a child directly and quickly.

Repeated malaria infections contribute to the development of severe anaemia, which substantially increases the risk of death.

Low birth weight - frequently the consequence of malaria infection in pregnant women - is the major risk factor for death in the first month of life.

In addition, repeated malaria infections make young children more susceptible to other common childhood illnesses, such as diarrhoea and respiratory infections, and thus contribute indirectly to mortality.

There are also potentially long-term consequences of the infection in children. Repeated episodes of fever and illness reduce appetite and restrict play, social interaction, and educational opportunities, thereby contributing to poor development (Africa Malaria Report, 2003).

A longitudinal cohort project undertaken between 1992 and 1994 in the Asembo bay area within the Lake Victoria basin, Kenya indicated a malaria parasite prevalence of 83% in 1-4 year old and 60% in 10-14 year olds (Bloland *et al.* 1999). Anaemia was reported in the same study to be consistently associated with high-density infection of malaria in children under 10 years of age. More than half of all pregnant women had haemoglobin levels of <11.0 g/dl, with up to 40% with a haemoglobin of <8g/dl in the peak malaria season.

3.14.3.4 Causes of malaria

Malaria is caused by a sporozoan parasite, which has a developmental cycle through man and mosquito. The lake basin experiences high rainfall resulting into stagnant water, which are potential breeding grounds for mosquitoes. The rains in the region are recurrent and the number of breeding sites is high making it difficult and expensive to control malaria. Further, like any other rural communities, acquiring insecticide treated materials including mosquito nets, is unaffordable. Besides, there are more pressing and competing demands for the limited resources that the communities have.

3.14.3.5 Mitigation against malaria

Malaria is curable if promptly diagnosed and treated. Control involves any or a number of the following approaches:

1) Protection against infection through prophylaxis,
2) Control of development of disease in infected individuals.
3) Personal protection using protective clothing, repellents, and bednets.
4) Community/population protection through insecticide spraying and environmental management.

Lack of laboratory facilities and medicines together with issues of treatment guidelines and training often result in inefficient prescription practices for malaria (Phillips-Howard *et al* 2003). The effectiveness of insecticide-treated bednets in reducing morbidity and mortality from malaria has been documented (WHO, 2000) and they can therefore be exploited in the fight against the disease. In a study within the Lake Victoria basin, permethrin-treated bed-nets have been shown to have a community effect of protecting non-ITN users who lived within 300 meters from users, thus increasing their attractiveness a control strategy against malaria (Wiseman *et al.* 2003). Drug resistance often impedes progress in the fight against diseases in the Lake Victoria region. An example is the consequences of chloroquine and SP resistance and the complex issues that surround changes in antimalaria drug policy (Shretta *et al.* 2000).

3.14.4 Diarrhoea diseases

3.14.4.1 Status of diarrhoea diseases

Diarrhoeal diseases are ranked fourth in outpatient morbidity causes in Nyanza province (Table 3.41). WHO estimates for diarrhoea related deaths/yr in under 5 years of age in their member States, within the African region is 701,000 representing 16% of total deaths (World Health Report, 2005). Africa also accounted for 80% of the total reported number of cholera cases globally in 1997 according to WHO (1998). Between 1997 and 1998, a clinic-based surveillance for diarrhoeal disease was conducted in Asembo, a rural area in western Kenya. Out of 729 diarrhoeal specimens collected, 33% yielded greater than 1 bacterial pathogen (Shapiro *et al*. 2001). Data showed high levels of water contamination especially along the inhabited shores of the lake. Water samples from the beach landing sites show high levels of faecal/bacterial contamination, sometimes causing sudden large outbreaks of cholera and dysentery (LVEMP, 2001).

3.14.4.2 Distribution of diarrhoea diseases

Diarrhoea is a disease that is widely distributed within the Lake Victoria basin, particularly in infants. Ironically, the fishing industry is often a culprit in this cycle of disease and poor health, as it leads to unsanitary conditions at beach landing sites, sometimes causing sudden large outbreaks of cholera and dysentery due to contaminated water. Water samples from beach landing sites around Kisumu have shown a high level of faecal bacterial contamination

3.14.4.3 Economic importance of diarrhoeal diseases

Diarrhoeal diseases in the Lake Victoria basin are caused by any number of micro-organisms, which include amoeba and bacterial infections. Intestinal worms can also be associated with diarrhoea episodes. Contamination of any drinking water increases the incidence of water-related diseases, such as cholera, amoebiasis, giardia, and cryptosporidium (Alterholf *et al.* 1998). Shapiro *et al.* (1999) reported significant association between drinking water, bathing from Lake Victoria and the risk of infection with cholera. Lack of latrines in the region and a proliferation of faecal matter also linked to widespread diarrhoeal diseases. In surveys conducted in Western Kenya, drinking Lake Victoria water and sharing latrines between multiple households has been shown to increase the risk of bloody diarrhoea (Brooks et. al 2003). It is estimated that only about *20%* of Kenyan rural population has access to

safe water, but the situation is worse for Nyanza and Western provinces, where it stands at only *8%.*

3.14.4.4 Impacts of diarrhoeal diseases

In the developing world, diarrhoea is the most important cause of disability-adjusted life years lost after acute respiratory illness (World Bank, 1993). Although less than 10% of persons habouring the cholera bacteria develop typical cholera with signs of moderate or severe dehydration, case-fatality rates, which can be limited to less than 1% in community with well established diarrhoeal disease control programme, can rise to as high as 50% in unprepared community. Water-related protozoal diseases tend to assume greater significance in HIV-infected individuals with immunocompromised status (Mwachari *et al.*1998).

3.14.4.5 Mitigation against diarrhoeal diseases

There are numerous causes of diarrhoea, which are highly preventable, with the only requirement being proper sanitation and safe drinking water to significantly reduce its transmission in a community. Cholera epidemic control and preventive measures include hygienic disposal of human faeces, adequate supply of safe drinking water and good food hygiene. The practice of hand washing with soap and water at "critical times" has been found to reduce the diarroheal diseases by 35 percent or more (Marieke and Caincross, 1993); pit latrines can reduce diarrhoea by 36 percent or more; and improved water quality reduced infection by up to 20 percent (Almedom *et al*, 1977).

The Kenya Ministry of Health has a National Cholera Task Force in collaboration with similar task forces set up at provincial and district levels (http://www.who.int/crs/don/1999_01_20/en/). Such task forces are can be greatly hampered by the poor infrastructure.

Drug resistance and prescription policies need to be closely and continuously monitored as there are records of resistance to antibiotics by cholera bacteria (Shapiro *et al.* 2001).

3.14.5 Schistosomiasis and other intestinal helminthes

3.14.5.1 Status and Distribution of Schistosomiasis

More than 200 million people in 76 countries globally are estimated to be infected with schistosomiasis, and approximately 600 million people are at risk of infection. The presence of abundant surface water sources and the accompanying water-related activities particularly increase the chances of bilharzia transmission. In Kenya, Uganda and Tanzania, studies show that most transmission of the intestinal form of bilharzia tends to be closely confined to narrow zones along the shores of large bodies of water such as L. Victoria where it is endemic and the intermediate host is found (Handzel *et al*. 2003). Helminthic infections are very common within the lake region. A 2003 study in Asembo bay area within the L. Victoria basin in Kenya (Handzel *et al*. 2003), reported that sixty-three percent of students were infected with one or more geohelminths with prevalence of 42% for hookworms, 22.3% for ascaris and 17.9% for Trichuris. Another study in Busia district, which also falls within the L. Victoria basin also indicated that helminthic infections were

exceptionally common among school children in Busia district in a different area of the L. Victoria basin (Brooker *et al.* 2000). They found an association between multiple infections with helminthes and intensity of infection, which may have consequences for nutritional status.

3.14.5.2 Causes of Schistosomiasis

Infection with schistosomiasis is associated with distance to the lake or other bodies of water containing the intermediate snail hosts. Risk is particularly increased with specific water-related activities such as swimming and collecting water. A 2003 study (Handzel *et al.* 2003) reported that all schools within 4 km of lakeshore had an average schistosomiasis prevalence of >20%, while all schools beyond 4 km of lakeshore averaged 5.7%. Helminthic infections in the lake basin are also linked to inadequate access to potable water (Toure, 2004). Drinking contaminated lake water and the practice of sharing latrines between multiple households has been shown to increase the risk of bloody diarrhea (Brooks *et al.* 2003).

3.14.5.3 Impacts of Schistosomiasis

Consequences of helmithic infections can range from light non-specific, acute, to chronic infections. Symptoms range from asymptomatic to symptomatic diarrhoea, pain on urinating, general weakness, abdominal pain, anaemia, malnutrition and impared growth and development, and substandard school performance. A study in the Lake Victoria region on nutritional status of pre-school children reported that the prevalence of stunting (height-for-weight), wasting (weight-for-height), and being underweight (weight—for-age) was 30%, 4%, and 20% respectively (Kwena *et al*. 2003). Severe infections can lead to consequences including bladder cancer, kidney malfunction, complications of liver and spleen, CNS involvement, and death. Genital schistosomiasis can potentially increase the risk of HIV infection

3.14.5.4 Mitigation against Schistosomiasis

Geohelminths can be targeted for control using various methods. In resolution 54.19, WHO endorses mass school-based deworming programs for intestinal helminthes in areas with infection prevalence over fifty percent, since this eliminates the need for costly individual parasitological screening (Warren *et al* 1993, WHO, 1992). School-based helminth control programmes have been identified as one of the most cost-effective health interventions (Hlth Pol. Plan. 1998). Targeted drug distribution strategy can be implemented for either schools or entire communities in the endemic areas, such as treatment of all children living within 4 km of Lake Victoria for both geohelminths and schistosomiasis. If school health programs are developed as part of community partnerships, they can provide one of the most cost-effective ways to reach all age groups in the community. There is the draw-back that non-school going children would be omitted, but treatment coverage would be large and beneficial. Other regions of the world such as Egypt, China, Brazil, and Morocco have had good success with schistosomiasis control. This should be viewed as encouragement to attempt well-planned strategies for the Lake region. Safe, cheap and effective drugs are available for the treatment of all the different intestinal parasite specie. Further, bilharzia and other communicable diseases control can also be promoted by encouraging of proper disposal of faeces and urine

and preventing water contamination or water pollution. Unnecessary contact with lake water such as bathing directly in the lake can also be discouraged.

3.14.6 HIV/AIDS

3.14.6.1 Status and distribution of HIV/AIDS

In 2003, HIV/AIDS was declared a national disaster in Kenya. Prevalence of HIV in the Lake Victoria basin stands at between 14%, and 16% compared with the national levels of between 6% and 7% (KDHS 2003), and is often linked to lifestyles. It is estimated that 21% of the total AIDS cases in Kenya are in Nyanza province within the Lake Victoria basin. Rates are particularly high (can be as high as 32.4%) among populations occupationally depended on the lake. Prevalence in a survey of men and women age 13-34 years in rural area bordering the lake was shown to be 15%. Fishing communities have been suggested as being among the highest-risk groups in countries with high overall rates of HIV/AIDS prevalence (Allison & Seeley, 2004)

3.14.6.2 Causes of HIV/AIDS

Transmission of HIV in the Lake Victoria region is mostly through:

i) Heterosexual contact
ii) Perinatal transmission
iii) Blood transfusion
iv) Mother-to-child transmission: 5-8% during pregnancy; 10-20% during labour and delivery; 5-15% during breastfeeding (Kingola, 2003)

While the levels of knowledge on HIV/AIDS vary, the majority of members of communities who live around the lake are aware of HIV/AIDS. They know one or more modes of prevention and transmission of HIV and appreciate that sexual contact is the major source of infection (Grellier *et al.* 2004). Despite this, sexual relationships within the communities are such that the majority of the people engaging in high levels of unprotected sex with multiple partners. While communities living around the lake are aware that condoms can protect them from getting infected with HIV, many indicate that they cannot afford to purchase one (SAMAKI, 2004)

Fishing communities, which are particularly vulnerable to HIV/AIDS are very dynamic. The fish crew migrate from one landing site to another on a seasonal basis following the fish shoal. These relatively high levels of mobility mean that the chances of HIV spreading from one community to another are high. Fishing communities are also relatively isolated from the outside world due to inaccessible roads, inadequate means of transport as well as inadequate access to HIV/AIDS support services. A study conducted in Kenya revealed that whereas all the people, living along the lake Victoria shores, who were interviewed, had heard of HIV/AIDS, 37.6 percent associated HIV infection with “contamination of blood, natural disease from God, small animal which can eat anything and curses for breaking social norms” (MoLFD/NACC, 2004). The reasons for the vulnerability of fishing communities to HIV/AIDS are varied and complex and may include (Allison & Seeley 2004):

1. Mobility of many fishermen (migration)
2. Time spent away from home
3. Access to daily cash income – in an overall context of poverty and vulnerability

4. Demographic profile
5. Ready availability to commercial sex in fishing ports and beach towns
6. Many women have a subordinate economic and social position in many communities in the lake region, and this makes them even more vulnerable to HIV/AIDS.
7. The women give sexual favours in order to be provided with fish

3.14.6.3 Trends in HIV/AIDS infections

HIV/AIDS was first reported in Tanzania 1983, in Kenya in 1984 and Uganda 1982. Two decades later, it has seen some reversal in its spread, with decreased national prevalence rates in the Lake Victoria riparian states, but it is still widespread and particularly so in fishing communities around the Lake Victoria (Allison and Seeley, 2004). In response to HIV/AIDS, multi-sectoral frameworks have been developed to guide national and sectoral responses to the epidemic. This has resulted into a reduction in national HIV infection rates averaging between 6-7 percent in the three East African countries. In Kenya, adult prevalence rates have dropped from 13 percent in the early 1990s, to 9 percent today (Kenya Demographic Health Survey - KDHS 2003). Pockets of high prevalence however exist, and anecdotal evidence from health workers in the lakeshore towns reveals a much higher sero-prevalence. HIV/AIDS infection rates rising faster in women relative to men (Allison and Seeley, 2004).

3.14.6.4 Impacts of HIV/AIDS infections

HIV/AIDS is a serious health problem, with great implications for the region's economy and a great contributor to poverty. AIDS drains both labor and capital from farming, seriously reducing harvest, and contributing to malnutrition. HIV/AIDS is believed to be the leading cause of death in adults aged between 15 and 50 in the lakeshore areas. It is most prevalent in the most productive age (15-49). Therefore HIV/AIDS typically strikes the most productive members of the household first, immediately putting a strain on the family's ability to feed themselve and provide healthcare. ILO projected that HIV/AIDS may cause a drop in economic growth by as much as 25% by 2020 in Sub-Saharan Africa because of death and illness among workers in their most productive years (ILO, 2000). The relatively higher levels of infant mortality rates in the fishing communities are linked to the high HIV seroprevalence rates. Up to 30 percent of mothers attending antenatal clinics in the lake basin were found to be HIV positive. Data show that about 25 percent of children born of HIV-infected mothers die by their second birthday, a mortality rate which is 2 to 2.5 times higher than those born of HIV-negative mothers (Ng'weshemi *et al.* 2003).

High prevalence rates of HIV/AIDS and other communicable diseases have budgetary implications; the cumulative impact of increased health care costs, loss of skilled labour, loss of women's productive time as many increasingly get involved in taking care of the sick, as well as the loss in productivity of the fisheries sector, carry a substantial cost to the economy and pose a real challenge to national poverty alleviation strategies. HIV/AIDS and other communicable diseases are critical developmental and health problems, which have significant implications on the region's economy and poverty reduction initiatives.

As the fisher folk become infected, many engage in inappropriate fishing practices thus undermining fisheries resources management and development efforts. This results into a reduction in fish catch and incomes, as well as declining nutritional levels. A NAADS (2003) study conducted in the Lake Victoria crescent agro-ecological zone reports a reduction in annual fish catch in the 43 percent of the fishing households that were affected by HIV/AIDS. Incontrast, only 20 percent of the households not affected by HIV/AIDS reported declines in catch between the same period (1997-2002).

3.14.6.5 Mitigation against HIV/AIDS infections

Strategies for mitigating negative impacts of HIV/AIDS include: political commitment; development of communication infrastructure and accessible and equipped health facilities; public health issues by health sector agencies, Beach Management Units (BMUs) and Non Governmental Organizations (NGOs); education and health care provision by these agencies; Health facilities (Voluntary Counselling and Testing (VCT) centers, Prevention of mother-to-child transmission- (PMTCT), Access to anti-retroviral drugs (ARVs) and improved TB/HIV programmes); Better nutrition (Fish are vital sources of important nutrients and vitamins, particularly to the poor and Fish products contain 12 of the 15 vitamins and minerals most important for the health of HIV/AIDS affected persons (FAO, 2004)); wider social service provision and economic support; incorporation of HIV/AIDS awareness in planning of major regional and national fishery development programmes; ensure the revision and creation of legislation on HIV/AIDS (Beckman and Rai, 2004), enhanced research.

3.14.7 HIV/AIDS co-infections and opportunistic infections

The Lake Victoria basin is a region of multiple occurrences of infectious diseases, sometimes at very high prevalence. Research indicates interactions of HIV and other communicable diseases, and important public health implications, which remain unanswered (Secor *et al.* 2004). Placental malaria, infant malaria, and HIV infection of infant have been reported to be associated with infant anemia (van Eijk *et al.* 2002), making infants especially vulnerable to the adverse consequences of malaria.

3.14.7.1 Tuberculosis (TB)

Tuberculosis is a disease that is spread from person-to-person through the air, and it is particularly dangerous for people infected with HIV. The fact that HIV infection severely weakens the immune system leads to people dually infected with HIV and TB to have a 100 times greater risk of developing active TB disease and becoming infectious compared to people not infected with HIV. CDC estimates that 10 to 15 percent of all TB cases and nearly 30 percent of cases among people ages 25 to 44 are occurring in HIV-infected individuals. Worldwide, TB is the leading cause of death among people infected with HIV.

This high level of risk underscores the critical need for targeted TB screening and preventive treatment programs for HIV-infected people and those at greatest risk for HIV infection. All people infected with HIV should be tested for TB, and, if infected, complete preventive therapy as soon as possible to prevent TB disease.

3.14.8 Conclusions and recommendations for better health

The Lake has a direct influence on the health and nutritional status of the communities around it particularly impacting on water-related diseases. Current capacity to cope is low, and the pressures on the environment and the lake, which result in compromised health status and food insecurity, continue to rise. A common regional and global partnership approach to improved health security within the Lake Victoria region is required. There is a need for a clear identification of opportunities available, in order to mitigate potentially adverse environmental impacts and to identify opportunities for beneficial impacts. The aim should be to contain known infectious disease risks, to detect and respond to unexpected infectious disease risks and to improve preparedness and public health infrastructure. Community involvement and participation in health issues that affect them should be encouraged.

There is a need to integrate more strongly health policies into other development programs. Parallel pursuance of poverty alleviation, population growth and health policies should be reassessed to find linkages that can be exploited for maximum impacts. Better management of the lake from accurate, reliable and continuously updated information bases is an integral part of better health management in the region. Successful management will require such information bases as disease distribution maps and models, which are continuously and regularly monitored for health and disease status of the communities in the region. This allows for easy and clear definition of risks of health events for individuals over time. Health data bases will then enable the development of risk assessment strategies, early warning systems for disease outbreaks and workable coping strategies.

3.15 Socio-economic and Development Setting

This section examines the likely implications of interactions between socio-economic conditions and the environment in the Lake Victoria. Lake Victoria is a multi resources area and includes sizeable fisheries and other bio-resources, transport networks and potential for tourism. The current trends of exploitation are not conducive for their sustainable exploitation. High poverty levels, unemployment, and inadequate social services, are widespread with the Lake Victoria basin. These are conditions, which do not encourage the best use of natural resources. Incomplete or inappropriate development and environmental planning-including the absence of appropriate national and regional policies, legislation, and regulation-hamper optimum use the resources. Underdeveloped civil society and the consequent lack of accountability and transparency limit public participation in environmental and development planning.

3.15.1 Gender and development

3.15.1.1 Issues in Gender and Development

Women are resource managers and producers in Africa. They are the key actors in the management and use of soil crops, water, forests, indigenous plants and wildlife in which communities depend. Subsistence farming in Africa is carried out by women (70-80%). African women dig, plant, weed and harvest. African men clear and fell trees. African women and men usually carry out distinct agricultural tasks. Animal husbandry is the work of men and women. Women are responsible for

water, fuel wood, and animal fodder collection. Women are familiar with traditional medicinal plants and herbs, maintained in home gardens.

Rural women are consistently responsible for the collection, preparation and use of fuel wood and water throughout Africa. Women uphold cultures traditions that govern the use of forests, rivers and trees.

Women's initiatives to preserve, protect and manage the resource base sustainably have deeply influenced family health and local and regional development. Women work against constrains and equities. With changing social, economic and ecological conditions, women's duties and burdens grow while their poverty increases and resource degradation intensifies.

3.15.1.2 Constraints in gender development

Key constraints in women's effectiveness in natural resource management are heavy labour burdens, economic barriers, biased tenure systems and legal injustices, lack of support from institutions, lack of appropriate technology, inequalities in policy and power and resource degradation.

3.15.1.3 Heavy labour burdens

Women work for longer hours than men as they manage production and maintenance. This gender-based imbalance in labour reflects the obligations of traditional customs, changing social and economic realities and increasing resource degradation. Heavy workload contributes to a downward spiral of poverty for women and their dependents. As labour demands increase, men and women often opt for large families - a logical way to distribute the workload, but also a strain on resources and health.

3.15.1.4 Poverty and economic barriers

Poverty is a major barrier to sustainable development in Africa. Much of women's work is unpaid and does not even register in economic data and labour statistics. In male-headed households, women rarely control or have an equitable share in the family income and expenditures. Women face difficulties getting credit. SAP hurt women as producers and resource managers. Feminization is not related to lack of effort or competence among women.

3.15.1.5 Biased tenure systems and legal injustice

Sustainable resource use depends partly on local people's ownership and control of land and other resources and on the sense of security this provides. Women lack access to and tenure of land and use other natural resources. Women rights to land ownership are prohibited or restricted by state laws and traditional norms. Community property rights provide women with access to land. Because women lack basic rights to land, women are forced to use marginal lands to cultivate food crops, leaving the most productive areas to cash crop production.

3.15.1.6 Lack of support from institutions

Institutions do not have adequate capacities and incentives to address gender-differentiated roles and that they neglect the needs of girls and women. Agricultural

institutions accord relatively little attention and service to the activities that women undertake as both subsistence and cash crop producers.

3.15.1.7 Lack of appropriate technologies

Lack of access to appropriate technology constrains rural women in Africa. Needs of the poor have not been adequately met by technical innovations. The design of agricultural and environmental technologies hardly considers women's needs. Developing appropriate technologies for women can improve food production and forest management.

3.15.1.8 Inequalities in policymaking and power

Women are seldom involved in political systems and decision-making. Women are rarely involved in community government or leadership.

3.15.1.9 Resource degradation

As environmental degradation worsens, women spend more time and work harder meeting daily food and energy needs. As fuel wood sources become depleted, land becomes denuded, soils erode and water sources dry and become polluted.
Total time spent on fuel wood collection is growing as forests get cleared for timber extraction and agriculture. Dung is used as energy source for cooking instead of as fertilizer.

Water collection requires women to walk longer and longer distances as water supplies get depleted. More time spent on collection of forest products and water means less time spent on food production or other income-earning activities.
As land becomes degraded, soil quality and productivity decline and women spend time trying to produce the same from less.

The decline of water supplies takes a toll on sanitation as well as leading to the spread of infectious diseases and to other health problems.
The loss of plant genetic diversity, along with the increasing diffusion of uniform crop varieties is an environmental trend that can have gender-differentiated impacts.

Women with unique knowledge of the values of multiple species in polycultural home gardens lose status and opportunities when medicinal plants are replaced by cash crops.

3.15.1.10 Women empowerment

In order to empower women and ensure gender equity, there should be support and capacity building to strengthen women's rights and influence.

i) Increase economic opportunities for women.
ii) Build and strengthen women knowledge and skills.
iii) Ensure access to and control over resources.
iv) Strengthen the capacities of institutions to respond to and meet women's needs.
v) Reforming agricultural institutions to build equitable opportunities and services.

vi) Reforming educational institutions to ensure girls and women gain rights to education.
vii) Increase the development of and access to technologies suited to women's needs.
viii) Build women's political empowerment, leadership and equity in policy and decision-making.
ix) Issues of nutrition and health of the family

3.15.1.11 Opportunities

Opportunities available to women should be looked at from the following areas of value of groups; economic opportunities, women's indigenous knowledge, access and control of resources, institutional reform, education, appropriate technologies and political elmpowerment and decision-making.

3.15.1.12 Value of groups

Women groups tend to be more active in environmental activities because women suffer from resource depletion. By pooling their energy, women groups compensate for their lack of tools, resources and power in their struggle against soil erosion, water loss and fuel wood shortages. Groups organizing for sustainable development initiatives among women should be recognized as valuable and should be encouraged by local, regional and national leaders.

3.15.1.13 Economic opportunities

Economic opportunities for women help develop the community and improve natural resource management as well as empower women. More economic opportunities should be given to women banks and credit institutions should account fully for women's contributions and constraints in their lending practices.

3.15.1.14 Women's indigenous knowledge

Women's indigenous knowledge of natural resources provides an important but usually neglected asset. The knowledge, skills and insights of rural women should be fully recognized, valued, used and developed in sustainable development efforts.

3.15.1.15 Access to and control of resources

When women's rights over resources are protected and secure, the natural environment is better protected and used and families and communities benefit. Significant policy changes and actions are urgently needed to establish, protect and increase women's rights to land and other resources and women must be included in decision making related to land and resources policies and allocation.

3.15.1.16 Institutional reform

Governments need to recognize that providing agricultural extension to women will pay off for the larger society. Agricultural institutions should reform their operations and staffing to address women's needs. When possible, such efforts should be combined with those of other groups such as NGOs.

3.15.1.17 Education

Education is identified as a great opportunity for overcoming gender biases and furthering social and economic development and resource management. Educational institutions and programmes should take steps to close the gender gap in schooling and literacy rates and to provide women with equitable opportunities.

3.15.1.18 Appropriate technologies

To meet the needs of the poor, technologies need to be adapted to local resource limitations and risks needs to be kept low. These caveats are especially important for women, who are often the main suppliers of family food and cannot afford to take risks. Government, research institutions and other development decision makers must design, promote and discriminate environmental and agricultural technologies that meets women's needs and must ensure that women have access to useful innovations and information.

3.15.1.19 Political empowerment and decision-making

Despite persistent obstacles, women are slowly making gains in local, regional and national decision making and political. Government, advocacy groups and other development decision makers must work for women to help them gain opportunities, rights, support and strong rates in leadership, government, politics and decision making in natural resources management decisions and policy making.

3.15.2 Human development and sustainable livelihood

Most of the Lake basin is rural. The census results indicate that only about 7.8% of the basin population lives in urban set-up, compared to 19.4% national average. There is net outflow of population out of the basin, most likely to the major cities, of about 3.6% for males and 2.6% of females per year. These figures are above the national average, estimated at 1.5% for males and 1% for females.

The total fertility rate (defined as the number of children a woman is expected to give birth to in a lifetime) is 5.9, compared to the national average of 5. The crude birth rate (measured as the number of children born per 1000 people) was estimated at 46.2, compared to 41.3 average for the country. The lake basin, however, has very high mortality rate. Out of 1000 live births, 90.4 children will be expected to die before reaching the age of 5, compared to an average of 77.3 children nationally. The life expectancy in the lake basin stands at 49.2 years for males and 55.2 years for females. Comparatively the national life expectancy is 52.8 years for males and 60.4 years for females. The mean age in the basin is quite low, at 16.8 years, compared to 18.3 years national average. Unemployment rates are quite high in the basin, where only 19.7% of the population is in active employment, compared to 27.9% national average. There may be some variation in the demographic information since the last census, however, these are not expected to be very significant.

3.15.3 Demographic characteristics

3.15.3.1 Human Development and Livelihood Indicators

A summary of selected demographic information for the Lake Victoria basin in Kenya is presented in Tables 3.44 and 3.45 and Figure 3.29, based on results and

projections from the results of the 1999 population census. Those results indicate that the Lake Victoria basin, which covers 28 districts in Kenya, had a population of about 11 million people, in an area with a population density of 342 persons per square Km. This is way above the national population density of 49 persons per square Km. The average household size in the lake basin was 4.7, compared to the national average of 4.4. About 39.6% of the household in the Lake Victoria basin were headed by females, compared to 36.7% for female-headed households nationally.

Table 3.44 Summary of demographic information

	Lake basin	National
Population (million)	11	30
Population density (per km$^{2)}$	342	49
Average household size	47	44
% of urban population	7.8	19.4
Total fertility rate (children per woman)	5.9	5
Infant mortality (per 100 live)	90.4	77.3
Life expectancy at birth (males)	49.2	52.8
Life expectancy at birth (females)	55.2	60.4
Median ages	16.8	18.3
% of population in wage employement	19.7	27.9

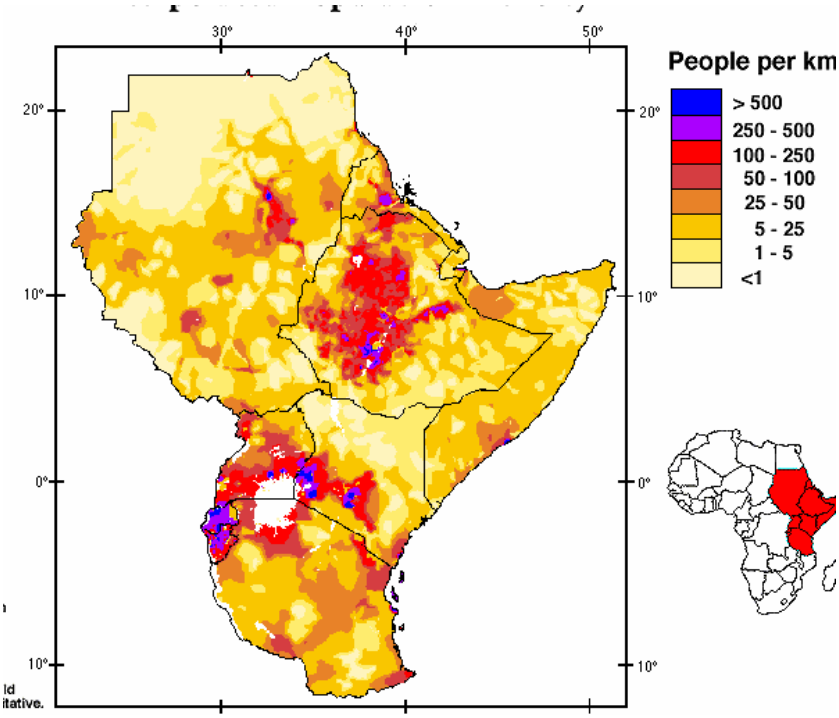


Figure 3.29 Population densities in the greater horn of Africa

Table 3.45 Lake Victoria basin (Kenya): Demographic information (Source: From 1999 Kenya Population and Housing Census)

District	Resident Population ('000)	Area (Km^2)	Density (Persons per Km^2)	Average household size	% of female-headed households	% of urban Population	Net Migrants (%)		Total Fertility Rate (per woman)	Crude Birth Rate (per 1000 Population)	Infant Mortality (per 1000 live births)	Life Expectancy at Birth (Yrs)		Median age	(%) Active population in Wage Employment
							Male	Female				Male	Female		
Kenya (National)	**28662**	**581677**	**49**	**4.4**	**36.7**	**19.4**	**1.5**	**1**	**5**	**41.3**	**77.3**	**52.8**	**60.4**	**18.3**	**27.9**
Bondo	238	987	241	4.2	48.4	5.1	-0.1	4	5.8	45.3	114.6	38.3	43.9	17.7	18.7
Gucha	461	661	697	5.1	36	2	-7.6	-4.4	5.1	44.8	90.3	52.4	61.3	16.8	13.6
Homa Bay	288	1160	248	4.3	46.7	11.5	-7.9	-4.3	6.1	50.8	149.2	35.9	40.7	17.1	11.7
Kisii Central	491	649	757	4.8	38.3	5.5	-7.9	-5.2	4.8	42.8	70.1	50.5	60	17.1	17.7
Kisumu	504	919	548	4	41.2	39.2	-2.3	-2.8	5	43.5	123.5	37.8	43.2	18.6	33.5
Kuria	152	581	261	5.2	39	7.8	-0.3	1.3	6.9	54.3	77.9	49.8	55.4	15.5	11.8
Migori	514	2005	257	4.5	44.8	10.4	1.2	4.4	5.9	50.5	143.4	37.8	42.8	17.1	17.3
Nyamira	498	896	556	5	36.9	5.6	-5.6	-3.8	4.7	43.4	25.6	59.2	67.2	17.1	18.5
Nyando	300	1168	257	4.3	43.8	10.7	0.4	1.3	5.7	44.1	116.1	37.7	42.9	17.7	25.4
Rachuonyo	607	945	325	4.5	47.5	3	-7.9	-4	6	48	110.6	39.4	44.4	17	15
Siaya	480	1520	316	4.1	54.6	4.2	-18.6	-18.9	5.7	42.7	135.6	36.9	43	18	13.6
Suba	156	1055	147	4.6	44.5	5.1	1.8	4.7	5.9	49.9	146.9	36.5	42	17.2	20
Bomet	383	1882	203	5.4	38.7	1.2	-9.4	-7.6	6.6	48.8	34.7	62.2	70.1	15.4	15
Buret	317	955	332	4.9	26.5	1.7	7.1	4.6	6	46.9	38.9	57.8	63.3	17.1	37
Kajiado	406	21903	19	4.1	37.9	20	13.5	1.2	4.9	40.9	47.9	60.3	67.1	18.2	34.5
Kericho	468	2111	222	4.8	33	2.9	-4.6	-5.1	5.4	43.2	62.1	54.8	62.5	17.5	23.1
Nandi	578	2899	200	4.7	29.1	7	0.5	-0.8	6	44.3	56.5	56.6	63.7	17.5	30.6
Trans Mara	171	2846	60	5.1	29.4	4.2	1.7	1.1	7.4	54	67.2	59.7	58.2	17.2	28.5
Trans Nzoia	575	2487	231	5.1	40.7	3.7	2.9	4.3	6.1	45.1	63	57.1	63.3	14.7	12.2
Bungoma	876	2069	423	5	35.4	10.7	-4.4	-3.8	6.4	46.6	97	54.3	61.5	16	17.9
Busia	370	1124	330	4.5	45.1	7.8	-8.8	-6.6	6.1	47.5	125.9	41	46.6	16.2	13.5
Butere-Mumias	477	939	508	4.4	40.9	8	-4.9	-1.4	5.9	46.4	132.1	45.3	51.6	16.5	19.3
Kakamega	603	1395	432	4.8	39.1	9.4	-17	-16.8	5.7	44	110.9	50.1	56.6	16.9	19.9
Lugari	216	670	322	5.2	40.4	4.3	10.8	14.8	6.1	44.8	64.1	57.4	64	16	18.7
Mt.Elgon	135	944	143	5.3	30.2	3.9	-5.8	-5	7.1	48.9	71.4	56.5	65.4	15.3	10.3
Teso	181	559	324	4.7	37.5	11	-0.9	1.4	6.5	49	84.7	48.8	52	16.1	14.7
Vihiga	499	563	886	4.7	44.7	5.5	-24.2	-21.7	5.1	37.6	81.9	53.2	58.7	17.4	19
Mean	405.3	2070.1	342.4	4.7	39.6	7.8	-3.6	-2.6	5.9	46.2	90.4	49.2	55.2	16.8	19.7

3.16 Disaster management

The concept behind disaster management is the need to permanently be prepared for the worst; its philosophy is to provide, to an actual or potential disaster, an effective system for;

a) Reporting
b) Assessing
c) Responding

Over 70% of disasters in Kenya may be attributed to extreme weather and climatic events (Odingo *et al* 2002). Based on past experiences within the Lake Victoria basin, the probable disasters that may occur include:

i) Accidents in the lake waters involving passenger ships/boats, with potential loss of human life
ii) Accidents in the lake waters involving transport boats, with potential to spill toxic chemicals/oils
iii) Accidents on roads involving vehicles with passengers/goods such as oil tankers with oils/toxic chemical resulting in fires and potential for contamination of water sources
iv) Fires from oil storage terminals e.g. Kenya Pipeline storage yards in Kisumu and fuel stations located in various urban centres.
v) Accidents involving rail wagons with passengers/dangerous cargo such as toxic chemicals/oils spills.
vi) Collapse of buildings
vii) Plane crashes
viii) Drought
ix) Floods, particularly in the lowland plains and river estuaries around the lake.
x) Land slides involving mining of sand, building stones etc with loss of human life.

It's important to classify disasters based on the potential impact and response measures e.g. In case of toxic chemical/oil spill management, the quantities of chemicals/oils will determine the response initiatives and the organizations to be involved, based on Tier levels. The commonly used levels are Tier 1, Tier 2 and Tier 3. Tier 1 is a local spill, site specific and can be controlled by a company's own personnel or local fire brigade. Tier 2 is medium oil/oil product or chemical spill where a company cannot/has limited control of the event and needs some external assistance. Tier 3 is large-scale spill that may contain the risk to spread beyond national boarders and thus requires external intervention. Table 3.46 summarizes some of the common extreme weather and climatic events and associated impacts.

Table 3.46 Some Extreme Weather and Climate Events and Associated Impacts

Extreme Weather/ Climate	Areas-affected	Impacts
Droughts	Affects livestock, wildlife.agriculture, water resources	Deaths amongst other
Floods	Damage to crops, shelter, Infrastructure	Loss of lives, water resources, water quality
Hailstones		Damage to crops, damage to property, loss of crops, stock and human lives
Thunderstorms	Damage to life and property	Loss of human life
Lightening	Loss to human life, infrstructure	Damage to structures, shelter infrastructure, loss of life and aircraft accidents.
Strong winds	Damage to property, water transport	Loss of life
Extreme temperatures	Damage to crops and health	Effect on urban areas
Whirl winds	Damage to property	Damage to crops
High Lake Waves	Damage to transport and loss of life	Damage to life and property
High humidity	Effect on human health	Loss of life
Dust storms	Damage to life and property	Damage to crops

Adopted and modified from Odingo *et al*. 2006

Management of disasters is a multi-sectoral initiative involving various government and private stakeholders. For effective disaster management there is need to:

i) Identify a centralized control organization /center to coordinate activities of and communicate links between the various organizations and agencies involved in rescue mission and combating the disaster.
ii) Human Resources Development for disaster response activities
iii) Material resources availability for disaster responses
iv) Database Management
v) Information and Communication
vi) Education
vii) Research and development
viii) Public awareness
ix) Policy enhancement to the Kenya Meteorological Department (KMD) and Drought Monitoring Centre (DMC) to provide Information and Early Warning Systems to the Industry
x) Establish Post Event Assessment

3.17 Conflicts in Resource Use and Management

3.17.1 Conflicts in cross-border fishing and fish trade on Lake Victoria

The main reasons for cross-border fishing and fish trade have been identified as;

a) Piracy and robbery
b) 'Long liners' vs. 'drift netters'
c) Weak and non-transparent enforcement of law and regulations
d) Smuggling of fish and other goods
e) Hired gangs protecting private fishing interest
f) Uneven development of fish markets
g) Rapidly growing fishing effort
h) Over-capacity of fish processing plants

3.17.2 Conflicts in water use

The main conflicts in the use of Lake Victoria water resources arises from the treaty of 1929 signed between Egypt and the British Government which gave Egypt exclusive use of the Nile river waters while the countries within the Lake Victoria basin restricted from the use of the same waters.

3.17.3 Conflicts in forest resources

Due to high population growth, there is growing pressure for clearance of forests for timber, firewood and settlements which conflicts with the various policies for afforestation, environmental conservation and catchments protection.

3.17.4 Conflicts in use of wetlands and wetlands resources

Whereas the National Environment Management Authority (NEMA) Act, Wetlands (Ramser) Convention are for the protection and conservation of wetlands, the Policy papers on food security are for the enhanced production of food to alleviate poverty. These are policies that result in conflicts in regard to use of wetlands especially for agricultural purposes.

3.17.5 Conflicts in environmental governance

Environmental governance has emerged from increasing efforts to establish and understand the links between general governance issues and environmental management. It defines a body of values and norms that guide or regulate state-civil society relationships in the use, control and management of the natural environment (Mugabe and Tumushabe, 1999)

Environmental governance is still fragmented, diffused and overlapping due in part to the proliferation of multilateral environmental agreements (UNEP 2004). This overburdens the governments of the developing countries to participate in decision-making processes.

A number of environment issues need integration into the political agenda for improvement of environmental management. For example, the issue of isolating a certain region because of their political inclination might slow down the implementation of a gainful environmental project. The second issue of governance is related to a regional implemented protocol that might not be signed or is implemented by one country deterring full execution of the protocol. Third, lack of

political goodwill to change an environmental policy might lead to continued degradation until the right political decision is taken.

The Action Plan of the Environment Initiative for New Partnerships for Africa's Development (NEPAD) emphasizes combating land degradation, drought and desertification; wetlands, invasive species, marine and coastal resources, cross-border conservation of natural resources and climate change. The plan addresses the related problems of pollution, forests and plant genetic resources, freshwater, capacity building and technology transfer. The implementation of the plan requires the support by African countries that are members of NEPAD.

3.18 Environmental information management

Consensus has emerged about the importance of information for environment policy analysis and formulation. Weak information management has weakened effective natural resource planning. Environmental information systems (EIS) can address the problem by making it easier for information and subject specialists to provide policy makers with timely, accurate and appropriate data. There is need to adopt the ecosystem model approach to natural resource management (Scenario 1 or 2).

3.18.1 Environmental information systems

There are two basic approaches to ecosystem model that could be adapted to environmental information management. The first approach involves ecosystem model in its traditional application that involves the assessment of biomass and fluxes within an ecosystem. The second approach emphasises the ecosystem models approach but in addition the overall importance of these systems in terms of ecological, economic and socio-cultural considerations are attached values. The ecosystem model approach integrated with damage schedule approach stresses ecological impacts of resource exploitation and its effects on economic and socio-cultural values (Chuenpagdee & Vasconcellos 2000).

The damage schedule approach emphasises non-monetary valuation tool that aids policy makers in their decisions about management of resources when public interests are of prime concern. The approach allows scientific knowledge, traditional knowledge as well as people's preferences and values to be incorporated in the same framework. It uses a ranking of relative importance of resources obtained using a method of paired comparisons. It provides an alternative to valuation method that rely either on a comprehensive knowledge about resources, such as the changes in productivity or monetary estimates of the resources, such as the contingent valuation.

3.18.2 Role of environmental information systems

EIS (including GIS) can enhance cooperation and coordination among institutions. EIS can help analysts identify information needs. Through the preparation of maps and statistics, guide decision-making. Well-designed EIS provides an institutional framework for guiding and building information management. GIS is a technical tool for integrating spatial data of different types. GIS can also help to answer the 'what if' questions that lead to practical policy options. The guiding principle behind the design and implementation of strategic plans and their supporting information management systems is stakeholder participation. This is prerequisite for the

development of common data standards and other building blocks of effective information management.

Information management is required in order to present information accessibly and convincingly to decision makers and move information systematically and rigorously at all levels of decision-making. These can be fully met by exploiting the power of GIS and related computer-based technologies. These technologies can offer a holistic view of natural resource conditions and trends and allow users to formulate broad-based and longer-lasting solutions to environmental degradation.

The rapid data retrieval and recombination qualities of GIS allow users to generate precise and timely maps and statistics that help answer policy-related questions. GIS allow spatial data, whether economic, environmental or social etc to be integrated into new and imaginative ways.

It is paramount that priorities are set for information needs with the following steps in mind: first to choose an appropriate institutional framework, second to decide what support is needed for the programme, and third to form an EIS working group to act as a steering committee and make decisions on standardization, data compatibility and similar technical issues.

There are five priority areas of data centres one natural resources management, namely, soil and water management, water resources, agricultural planning, lands and surveys, geology and forest cover, fisheries resources and wetland conservation.

Bibliographic, statistical and map information from these centres will be developed according to database architecture proposed by EIS community. EIS ensures availability of timely, appropriate and compatible information for decision- making. EIS should also depart from the traditional routine data collection to a more demand-driven type of data management. There is need to provide a viable mechanism for consensus building ensuring that the data collected are relevant and get used.

GIS can help bridge the gap between the analyst and the decision-maker by ensuring that raw data is converted into a form that decision makers can grasp. The integration of social and environmental consideration into national policies is imperative of sustainable development according to Cairo conference on population and development September 1994; Beijing women's summit (September 1995); and Habitat II Conference (June 1996)

There is need to integrate local policies on the environmental poverty alleviation strategies and population policies. It is important to plan multi sectorally to address both social and environmental issues and their implementation that require functional linkages to encourage dialogue and consensus building as a prelude to data sharing. Need to share information can stimulate the development of common data standards.

3.18.3 Regional Cooperation

Despite significant national progress to improve data access and exchange regionally in Africa, environmental information is not readily shared. Getting

countries to share environmental information is therefore a critical challenge. Improved analysis and decision-making as well as cost effective use of relatively expensive data must spring from genuine cooperation and willingness to share digital data, particularly digital maps. Analysts need larger scale maps and data to access environmental conditions and trends and to propose solutions to environmental degradation at national sand sub national levels.

Regional organizations can offer a viable institutional base for effective information sharing in Africa by providing a mode of information exchange and help national EIS specialists to develop data standards, increased cooperation and coordination can help implementation of conventions that have regional and global dimensions. Regional databases could greatly help signatories to implement conventions that are inherently transboundary.

3.18.4 Information network

3.18.4.1 Capacity building of information networks

There is need to build technical capacities if current national efforts are to be sustainable. Centres of excellence should be developed to coordinate activities, training and enhance capacity building needs. International communities should give regional organization's support to build national capacities. Effective networking is required at national, regional and individual levels.

Useful networks could be established to exchange information and share development lessons learnt. Network for information management practitioners could disseminate information to their members, organize workshops to share experiences and implement member-training programmes. These networks can also help consensus on data standards, definition of regional priorities and the development of regional databases.

3.18.4.2 Sustainability of information networks

Sustainability is fundamental to the success of EIS programmes and with the advent of these programmes necessary strides can be made towards cost-effective information management. Demand driven EIS programmes can cut down on traditional costs related to information management. Technology is becoming increasingly affordable and analysts should make functional systems simple.

Policy-makers should promote national ownership of information management programmes, through dialogue and consensus building. The EIS also need to generate revenue to become self-sustaining and build partnership with the private sector, NGOs and other stakeholders who could use the information products and services from these programmes. Sustainable financing mechanisms can help in maximizing the potentials of EIS to serve the stakeholders' needs consistently. The current overall trend of internet connectivity in Africa is strongly positive though socio-economic measures of internet penetration is still slight.

3.18.4.3 Internet arrangements within information networks

Internet highways are an avenue to a number of communication channels and this has been improving by day. Currently, the thinking is in support of Wireless Local

loops (WLL) compared to the dial ups and leased lines. Licences are being granted for Public Data Network Operators (PDNO) that have the advantage of improved pricing and reduction in the total cost of internet leased lines. Secondly, customers can now benefit from service guarantees and thirdly, installations can now be done very fast. These benefits – price, reliability and speed of installation – together with other minor ones have improved internet and general connectivity services in Kenya.

3.18.5 Current status of Environmental Information Systems

Currently data and information is kept by different stakeholders in hard copy forms, only a few of the stakeholders hold their information in electronic forms.

3.19 Improving Inter-sectoral Coordination

Government, research institutions and other development decision makers should design, promote and disseminate environmental and agricultural technologies that meet the needs of key stakeholders, particularly women. Different institutions should coordinate and formulate policies that are in harmony, to avoid conflicts. For example while struggling to conserve wetlands, the agriculture policy stands to drain all wetlands and turn them into agricultural land.

Africa's ecosystems and their biodiversity are particularly crucial from the perspective of realized and potential goods and services for the entire globe. A recent list of the world's centers of Biodiversity identified 18 'hotspots'; four of these are in Africa based on high plant endemism and threats from human activity. Areas of high species richness often signify untapped potential for future goods including new food crops, medicines for incurable diseases, timber and non-timber forest products.

In terms of ecosystem services, Africa's forests are a huge "sink" for carbon dioxide that would otherwise be released into the atmosphere without potentially disastrous climate change consequences. Marine ecosystems are used for inter and intra regional transport. Efficient implementation of development projects depends on the availability and strength of institutional structures and arrangements. Many funding agencies have increased contributions for institutional development.

Strategic planning processes create opportunities to move from sectoral to cross-sectoral approach in planning and implementation. This can only succeed through the design of an effective institutional framework for coordinated cross-sectoral environmental management. These can only be done through the traditional government structures based on sectoral ministries and departments.

Building an effective environmental policy framework requires effective environmental institutions. Their main task will be to formulate and implement policy, carry out legislative reform, propose environmental programmes and projects, advise and support political decision-making processes, and set standards, collect data and evaluate environmental consequences of policies, decisions and projects; educate the public and coordinate and support work of governmental institutions, NGOs and civil society.

The intersectoral institution should have the capacity to plan for joint actions, in addition to information sharing and resource-sharing. Capacity building

(development) can answers a society's need to identify and solve its environmental problems. Capacity development includes training and education as well as organizational and institutional development. Capacity development is aimed at abilities in different areas and at different levels and it is highly dependent on prevailing political, social and economic conditions. Capacity needs to be built on the corporate sector as well as NGO's and communities.

Capacity development lacks integration at the planning process. Capacity development activities are designed narrowly focusing on sectoral needs. It should reduce or eliminate sectoral thinking. Capacity development should be availed to a broad number of stakeholders whose personal perceptions, experiences, attitudes and choices constitute the decisive factors in national-level efforts to manage the environment.

Government should establish appropriate relationship in planning among the multisectoral programmes that are involved. Capacity development training should embrace critical skills involving integrated management to decision makers through seminars and shorter courses. Pilot projects should be designed and implemented to demonstrate sound environmental management and help build local capacities. Pilot projects should be designed in consultation with local communities so as to reflect their priorities and experiences, strengthen indigenous environmental expertise and raise public awareness.

Successful local capacity development entails providing adequate and relevant training for extension agents who work with local communities. Resources for programme implementation should be allocated for strengthening the delivery capacities of formal and informal training institutions.

3.20. Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis for the Lake Victoria Basin

The SWOT analysis is a tool for undestanding and decision-making for all sorts of situations in programme planning. It provides for reviewing strategy, position and direction of a programme. SWOT is an acronym for strengths, weaknesses, opportunities and threats. Strengths and weaknesses focus on the present factors, while opportunities and threats reflect the influences of the external environment affecting the industry. Strengths and weaknesses are, respectively, those positive and negative attributes of the industry, its activities, location etc. that are presently felt. Opportunities and threats are the positive and negative factors, respectively, that may have impact on the future of the industry.

The Lake Victoria basin has several strengths, weakness, opportunities and threats for each specific sector. The specific SWOT analysis for the primary sectors is given in table 3.48.

a) Strengths

i) Human capital-availability of labour
ii) Fisheries- employment, income, animal proteins, raw material for the manufacture of animal feeds
iii) Lake Victoria-fresh water source

iv) Natural resources e.g land, water, wetlands, forestry, pasture, wildlife, cultural sites, energy (solar, wind, hydro), minerals
v) Political cohesion.

b) Weaknesses

i) Poverty
ii) Lack of morale, commitment, lack of efficient eadership, awareness
iii) Social-cultural factors-
iv) Lack of new technologies

c) Opportunities

i) Large market potential
ii) Industrial development
iii) East African market

d) Threats

iv) Politcal uncertaininity,
v) Legal weaknesses,
vi) Environmental factors-unreliable rain,draughts,floods
vii) HIV/AIDS
viii) Water born/vector diseases
ix) Decline in lake water levels.

Table 3.48. SWOT Analysis of the Lake Victoria basin primary sectors

Sector	Strengths	Weaknesses	Opportunities	Threats
Mining	The lake basin has significant quantities of unexploited minerals such as Gold, Carbonates (limestone), Soapstones, Phosphates, Sulphur, Kaolin, clay, quartze, Iron ore, Graphite, Diamond, Building and construction materials	• Small scale prospecting and mining in the region is not well organized resulting into uneconomic exploitation and accidents • The various minerals have not been quantified and the potential for mining established	• A new law is in advanced stages of formulation to enhance participation by small scale operators and to bring mining in line with environmental and health standards that will protect both the environment and the mining communities • The Department of Mining and Geology has offices in the basin which should give advice to prospective miners and investors	• Declining mineral deposits • Sinking of mine wells • Environmental degradation
Water	The lake basin is endowed with vast water resources in form of surface water and groundwater. The basin has the world's second largest water mass in the world. In addition there are small waterbodies in form of satellite lakes, rivers and dams	• Weak laws • Lack of awareness •	EMCA (1999) has provision for the protection of water resources and against polluting the water systems	• Droughts have led to decrease in the lake levels • Abstraction of water for hydroelectric power • Introduction of invasive plants with high evaporative rates • High levels of sediments, organic pollutants and nutrients
Agriculture	The basin is endowed with land	•	•	

Sector	Strengths	Weaknesses	Opportunities	Threats
and Livestock	and fertile soils.			
Forests	The basin has 460 000 hectares of gazetted forests.	•	• Opportunities exist for community based and managed tree nurseries • LBDA offers technical advice in forestry • Alternative sources of income exist in form of butterfly farming, honey production, ecotourism • The new Forest Act emphasizes on stakeholder involvement which promotes the exploitation of forest resources on a sustainable basis • ICRAF provides advice on agroforestry, Vanilla and Jatropha •	
Wetlands	The main wetlands in Lake Victoria basin include; Yala swamp, Nyando, Sondu Miriu, Oluch Kimira (Mogusi) and Gucha. Other smaller wetlands within the basin include Saiwa swamp (on the Nzoia river), Murula swamp (Eldoret) and Dionosoyiet in the vicinity of Kericho as well as seasonal floodplains. Wetlands in the Lake Victoria provide a variety of goods and services including building materials, mats, fisheries resources, buffering of pollutants and act as habitats for wild life, etc.	•	• EMCA (1999) and the draft Wetland policy aims at curtailing the rampant loss of wetland resources and ensuring that benefits from wetlands are sustainable and equitably distributed to all people of Kenya.	

Sector	Strengths	Weaknesses	Opportunities	Threats
Energy	The potential for energy production is vast and consist of hydro power, bioenergy, solar, wave, wind, geothermal. The potential for hydropower currently stands at 563 MW as follows; Nzoia- 159, Yala- 114, Nyando-14, Sondu – 249, Kuja Migori- 27 MW.	•	•	
Wildlife, Tourism (cultural sites	The basin is endowed with great geographic, cultural and natural diversity as tourist attractions	• Low level services • Poor infrastructure and few hotel facilities	• Opportunities exist in ecotourism, sociocultural tourism and sports. The Lake is endowed with culture diversity in form of folklores, traditional dancing troupes (Kochia dancers), bull fighting, wrestling, local dishes, watersports, bird watching (Yala Swamp), tropical forests, mountains, etc. • The basin can be linked to the Masai Mara circuit through Kisii and Trans Mara • Kenya Tourism Board is promoting the Western Kenya Tourism Circuit through the Western Kenya Tourism Masterplan	
Fisheries	• A variety of natural sources of fish • Predictable annual fish output • Well skilled and reliable fishermen • Developed local supply	• Over 90% of fish from one source, Lake Victoria • Over-reliance on one major species, Nile perch, for export • Seasonality of fish supply • Prevalence of destructive fishing gears and methods	• Increased exploitation of other inland fisheries • Greater production from aquaculture • Diversification to non-traditional fisheries • Increased output of marine	• Ineffective management of fisheries sources • Over-fishing using destructive

Sector	Strengths	Weaknesses	Opportunities	Threats
	network • Sufficient numbers of refrigerated fish transport trucks • Support services e.g. supply of ice to fish trucks • Liberalized fish pricing policy at all levels of industry • Many fish buyers and sellers, especially around Lake Victoria, means greater price competition • High retail price paid for Nile perch in the export market • Low level pollution in most fish sources • Well detailed EU quality specifications • Sufficient legislation on fish quality • The Fisheries Department already identified as the competent authority for fisheries sector • Regular inspection of fish processing establishment • Establishment of AFIPEK ensures self-regulation and joint action among fish processors • Comprehensive fisheries legislation (Fisheries Act) • Established Fisheries	• Fishermen lack gears and vessels for exploiting deep water e.g. motorised boats • Exploitation of fishermen by middlemen • Poor roads to fish landing beaches • Ice insufficient to serve fishing and fish transport boats • Too many sparsely distributed landing beaches • Fishermen not organized into strong bargaining units • Weak and ineffective co-operatives • Price information not disseminated to fishermen • Huge price fluctuations within the year e.g. low in rainy seasons • Fishermen lack cold facilities to store fish against low prices • Middlemen have too much power over fish price decisions • Duplicated levies on fish increases costs and prices • Significant post-harvest losses • Lack of a national fish quality control laboratory • Few sufficiently trained quality assurance personnel • Common practice of unhygienic fish handling at	fisheries, especially located off-shore • Increased fish imports from the neighbouring countries • Control of aquatic weeds • Concentrating fish landing beaches to reduce travel time and costs for fish buyers • A leaner marketing channel minimising role of agents • Ice production units close to fish landing beaches • Formalisation of fish import channels • Concentration of fish landings to improve market transparency • Developing business skills for the fishermen • Reorganization of structure for better marketing and bargaining power • Increased access to fish price information by all players • Increased direct negotiation between fishermen and factory owners • Establishment of cold-storage facilities on the main fish landing beaches • Reduced margin between the f.o.b price and export retail price of Kenya's fisheries exports • Greater training of Fisheries	gears and methods • Unsustainable catch levels • Siltation of rivers and dams • Pollution of fish supply sources • Uncontrolled aquatic weeds e.g. water hyacinth • Increased cross-border conflicts in the use of fishery products • Concentrating beaches might lower fishermen's profit margins through increased transport costs • Effect of international forex rates on local prices e.g. strengthening Ksh against US$ • Potential for

Sector	Strengths	Weaknesses	Opportunities	Threats
	Department • Established community-based authorities in fish landing beaches • Regional co-ordinating body, LVFO, in place • Involvement of major donor organizations in funding fisheries research and management • Well developed fish processing facilities • Close co-operation of factories across borders ensures shared information and resources • Well developed waxed packaging material and manufacturing industry able to export to the region • Existing fish export marketing network • High demand for the main export fish, Nile perch, in world markets • Reasonably efficient export logistical network • Ready access to ports of export both by air and sea • High demand for quality fish in local markets • Presence of a variety of preferred fish species that	beach level • Lack of sufficient infrastructure on landing beaches e.g. electricity supply and proper roads • Enforcement of quality control measures at production levels • Fisheries Department lacks transport and other facilities • Unprofessional conduct by some Fisheries Officers, especially at the local level • Community role in fisheries management not legally specified • Lack of enforcement in fisheries management • Relatively high labour costs of processing fish in Kenya compared to Tanzania and Uganda • Styrofoam packaging material has to be imported • Dependence mainly on two products of Nile perch • Long marketing chain in the export market • Inadequate export market information in terms of consumer trends, developments and preferences in terms of tastes, packaging, forms, species etc;	Department and factory personnel on quality control • Renovation of factory structures in line with quality requirement • Increased provision of toilets and other facilities in the landing beaches • Rehabilitation of waste treatment units in urban areas around fish supply sources • Legislation on the quality aspects of fish supply and processing • Increased surveillance of fishing and fish handling activities • Shift of fisheries management style to co-management by Fisheries Department, local authorities and other institutions • Improved relation between fishermen and Fisheries Department • Greater regional co-operation in legislation and enforcement • Increased global interest in fisheries research and management issues • Increasing shift of fisheries resource management to the local communities • Enhancing sustainable fisheries supply • Developing units of producing higher valued products	increased pollution in some fishing areas • Uncontrolled increase of human settlements around fish supply sources • Declining state funding of fisheries research and management • Retrenchment of Fisheries Department staff • Excess capacity indicating insufficient supply of raw material • Legislation in the market place on environmettal or anmantal e.g. munu • Frequent and prolonged bans on fish exports

Sector	Strengths	Weaknesses	Opportunities	Threats
	are locally consumed • Well developed fish distribution channels • Government effort to develop export markets e.g through multilateral and bilateral agreements and initiatives • Well detailed conservation legislation and policies • Established regional framework for management of Lake Victoria fisheries • Tariff policy that has reduced import tax of raw materials to 5%	competition, market entry conditions etc. • No enforcement of fish quality standards for domestic markets • Poor handling and packaging of domestically sold fish • Lack of facilities for proper fish marketing • Lack of effective enforcement of policies and strategies e.g. in resource management • Duplication in licensing and some fee payment e.g. fish traders' license • Lack of clear strategies to reduce the high costs of production e.g. communication and electricity • Lack of policy co-ordinating the different institutions in fisheries management • Lack of clear policy to reduce post-harvest losses	• Importing raw fillets and adding value for export • Development of credibility and importer-exporter trust • Introduction of value added export products • Expansion of market destinations for Nile perch such as USA and Far East • Diversification of exportable product range • Dwindling white fish stocks of cod and halibut in most global fisheries • Many potential domestic markets to be exploited • Campaigns to increase local fish consumption • Promote consumption of indigenous and non-traditional fisheries • Wide scope to increase aquaculture production of tilapia and *clarias* spp for domestic market • Government's initiative to involve the private sector in industry policy formulation e.g. AFIPEK • Policy of co-management of fisheries resources e.g. involving local communities	• Increased fish spoilage • Increased demand of fish by processing industry • Unsustainable fishing practices in rivers, lakes and dams • The change in EU-ACP agreement towards market liberalization might lead to increased competition for Kenyan products

SECTION 4. POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

This section discusses the legal and regulatory framework relative to trandboundary issues in the Lake Victoria basin. These include the international legal instruments and conventions, national legislations, policies and agreements.

At the global level and in Kenya, there is growing concern that development activities have the potential to cause severe damage to the environment. Development activities have the potential to damage the natural resource base on which the economies are based. The major challenge facing stakeholders and government today is how to institute sustainable development that protects the environment at the same time.

The legal and regulatory settings of the Lake Victoria basin should state the approach to preserving the environment of its catchment. The existing legal and regulatory mechanisms may provide barriers and mechanisms to sustainable resource utilization and effective environmental management. Therefore, this TDA section briefly reviews the following pertinent aspects of the legal regime:

a) Legal and regulatory mechanisms of the use and protection of the environment and natural resources of the Lake Victoria basin
b) Bilateral agreements
c) Regional agreements
d) Compliance with international environmental conventions
e) Institutional frameworks

The analysis focuses on the national legislation of Kenya, and those of the riparian states of Tanzania and Uganda, and the international treaties and conventions that have a direct bearing on the protection and conservation of the environment.

4.1. National Legislation on the Environment

There are several diverse pieces of legislation that have a direct bearing on environmental management. They include;

4.1.1. Environment Management and Coordination Act

The Environment Management and Coordination Act (EMCA) No.8 of 1999 establishes institutions and procedures for proper management of the environment, the conduct of environmental impact assessment, audit and monitoring, and penalties for environmental damage. All sectors are subservient to EMCA.

EMCA comprises of 14 parts covering all aspects of the environment including section 58, which cover issues related to Environmental Impact Assessment (EIA). The Act defines EIA as a systematic examination conducted to determine whether or not a programme, activity or project will have any adverse impacts on the environment. Section 58 further describes the condition that would warrant an EIA to be conducted including a schedule of the projects which must undergo EIA. Secondly, the schedule gives the list of processing and manufacturing industries, which must undergo EIA.

Other basic requirements include at what stage of the project EIA should be conducted, the project outline and who to take responsibility of financing the EIA process. The Act also stipulates the roles and responsibilities of all the stakeholders in the process. NEMA takes the responsibility to maintain a register of companies licensed to undertake EIA, receive the EIA reports, publish it for review, approve or reject the project, and eventually issue a license.

NEMA is expected to publish the names of investments with high potential for environmental degradation and, if need be, create deposit bonds as security to a safe environment practice, which can be confiscated if the investor does not keep good practice. The investor will therefore be cautious in its operations and at the same time the Authority will have funds at its disposal for immediate action if the activity of that particular investment leads to environmental degradation that would require rehabilitation. This is in line with the polluter pays principle as a means of ensuring that environmental activities do not cause deleterious effect on the environment.

In ensuring that the Act is operational in all its requirements, NEMA undertakes to appoint inspectors to undertake regular inspection of any activity or facility and report its compliance, and also take appropriate action to stop the degradation. In order to diagnose the health of all aspect of the environment, NEMA will undertake regular audits and report the state and provide appropriate advice. All facilities or developments already in existence when the law came to effect will therefore be required to undertake audits and report their compliance at the end of which NEMA is expected to issue a compliance license if satisfied that the standards are met as specified in the regulation as provided for in section 68 of EMCA. Further, NEMA will ensure sustainable management of solid waste through issuing license both to the producers and handlers of solid waste particularly the Municipal authorities and plants that produce effluents. All these are aimed at ensuring that the plants meet environmental quality standards as stipulated in part VII section 70, including standards related to water pollution.

To ensure compliance, the Act also gives NEMA the Authority to issue orders ranging from Environment Restoration orders, Easement orders and Environment Conservation orders when appropriate. These powers are also vested with the court of law for appropriate jurisdiction. It should be noted that NEMA works by delegation of most of its powers to the institutions created by the Act at the local level like the District Environment Management Committee and the Provincial Environment Management Committees. The decisions of these committees are legal and it is an offence not to implement them. The committees are also required to identify and deliberate on areas of environment significance and liaise with the Local communities for gazzettement, protection and conservation

The EMCA act (1999) is the overriding Act to all the other Acts with respect to environmental protection in Kenya. In the recent past, most of the establishments and projects that pose adverse effects on the environment in the Lake Victoria basin have conducted Environmental Audits to comply with the requirements of EMCA. All the new establishments and projects that may adversely affect the environment are also required by law to undertake Environmental Impact Assessment before they can be licensed to operate.

4.1.2. The Fisheries Legislation

There are two important legislations with regard to management, conservation and utilization of fisheries resources in Kenya, namely the Fisheries Act and the Fish Quality Assurance Regulations. Additional regulations include the European Union Directives and those of the Kenya Bureau of Standards.

4.1.3. Fisheries Act cap 378 laws of Kenya of 1991

This is the principle legislation regarding the management, conservation and utilization of Fisheries resources, including marketing and licensing fishermen and traders. It specifies the types and sizes of fishing gears and methods, the fisheries management institutions, the conduct of fishermen and other control measures. The Act creates the office of the Director of Fisheries as the chief officer responsible for fisheries matters in the country.

4.1.4. Fish Quality Assurance Regulations of 2000

The legislations provide for the Fisheries Department as the technical implementing body of the Competent Authority for purposes of quality assurance of Fish and Fishery products in Kenya. On 11th August 2000, the Minister invoked section 23(2) of the Fisheries Act to set out "The Fisheries (Fish Quality Assurance) Regulations 2000". These regulations address the gaps that had been observed in the Act with particular reference to assurance of fish quality and safety. The publication and official launching of the regulations led to the achievement of a one stop Competent Authority mandated to assure quality and safety of fish and to regulate fishing activities nationwide.

The Competent Authority in matters related to fish quality assurance is guided by the Fisheries (Fish Quality Assurance) regulations 2000, which states that the Competent authority shall be directed by a standing committee, which comprises Permanent Secretary to the Ministry who is the chairman, Director of Fisheries and the Director of Veterinary Services and Agriculture as members. The Standing Committee handles major decisions and interventions e.g. new establishments, and vessels, quota systems, awarding establishments and vessels with Certificates of Compliance and Permanent Reference numbers for export among other functions.

The regulation 2000 also states that the department shall work in collaboration with the Kenya Bureau of Standards (KBS) in the establishment of Kenya Standards for fish handling and processing. In circumstances where some standards are not covered in the aforementioned Act, the fisheries department invokes the Standards that are provided by KBS, which is the Kenyan standards body. The fish quality standards of Kenya are fashioned around the EU regulations, which was adopted by the fisheries department and incorporated in the Fisheries Act Cap 378, the Fisheries (Fish Quality Assurance) regulations 2000. The standards cover the sector across board from the fishing grounds, aquaculture to marketing of the fish and fishery products. The key feature of this Regulation is that it aims to achieve a health attestation of wholesomeness of all fishery products (whether fresh, chilled, or frozen) and all support materials that come in the preparation, processing, packaging, storage and transportation of the product.

The regulation imposes strict recommendations on the fishing grounds for any pollutants; controlling of fish landing, handling and transportation; approving new fish processing establishments on building, construction, equipment, water purification and operation of Fish processing plants and factory vessels. The regulation also gives recommendations to the competent authority on inspection of operational fish processing plants to ascertain compliance with the Kenya standards for handling and processing; services of laboratories for microbiological, physico-chemical, pesticide and heavy metal analysis of fish products are used with a provision of a health certification of fish and fishery products on the basis of Hazard Analysis and Critical Control Points (HACCP).

The regulation also lays down all the procedures to be followed for compliance with these regulations. It also gives guidelines on approving of establishments of fish markets; specifies conditions for placing on the market of fish and fishery products and maintaining a register of approved fish processing plants, auctions and wholesale markets and landing sites.

4.1.5. European Union Directives on Fisheries

EU Council Directive 91/493/EEC lays down the sanitary conditions for the production and the placing on the market of fisheries products from outside the EU. The Directive imposes strict recommendations on the building, construction, equipment, purification tanks and storage tanks. The premises are expected to have laboratories. Record keeping is paramount and there are clear guidelines on labeling of packaging material. The EU Council Directive 95/71/EEC – 95 amends the annex to Council Directive 91/493/EEC.

4.1.6. Kenya Bureau of Standards regulations applicable to fisheries

These are the Kenya Fish Handling Standards (KS05-1516) and the Specification for Drinking Water (KS05-459). This code applies to fish for human consumption and sets out the treatment that shall be applied to fish from the time it is taken from the source through all the stages in order that it reaches the consumer whether on the home market or export market in top quality condition. The document has adopted the EU directive 91/493/EEC with modifications to meet Kenyan export and import requirements. The Standards cover;

i) Advice to traders on food labeling requirements
ii) Sampling of foods to ensure compliance with compositional standards
iii) Monitor use by dates on food
iv) Carry out food surveys for national and regional clients
v) Visit retailers and manufacturers to ensure they comply with food legislation

The Lake Victoria basin contributes significantly to the fish exports. In view of this the Fisheries Department has set up two laboratories to strengthen the fish quality standards. Through funding from the EU-IFMP, the department has enhanced Monitoring Control and Surveillance (MCS) and many illegal fishing nets have been seized and destroyed. The Fisheries legislation is important in ensuring proper management, conservation and utilisation of fisheries resources in Lake Victoria and other water bodies in the basin.

4.1.7. The Forest Act

The forest Act 2005 is an act of Parliament to provide for the establishment, development and sustainable management, including conservation and rational utilization of forest resources for the socio-economic development of the country. The act recognizes that forests play a vital role in the stabilization of soils and ground water, thereby supporting the conduct of reliable agricultural activity, and that they play a crucial role in protecting water catchments in Kenya and moderating climate by absorbing greenhouse gases. In addition, forests provide the main locus of Kenya's biological diversity and a major habitat for wildlife as well as being the main source of domestic fuel wood for the Kenyan people. Forests also provide essential raw materials for wood based industries and a variety of non-wood forest products. Kenya is committed to the inter-sectoral development and sustainable use of forestry resources under international conventions and other agreements to promote the sustainable management, conservation and utilization of forests and biological diversity.The key elements in this act are:

i) Nothing in this Act shall be deemed to prevent any member of a forest community from taking, subject to such conditions as may be prescribed, such forest produce as it has been the custom of that community to take from such forest other than for the purpose of sale.
ii) A person who establishes or owns a private forest may apply to the relevant authorities for exemption from payment of all or part of the land rates and such other charges as may be levied in respect of the land on which the forest is established.
iii) In consultation with the forest conservation committee for the area where the indigenous forest is situated, the act notes that preparation of forest management plans is essential.
iv) In consultation with the minister responsible for mining, rules should be published to regulate and govern mining operations in forest areas.
v) The community may undertake any activity referred to in subsection (i) within a forest area and shall apply in that respect accompanied by the results of an independent Environmental Impact Assessment conducted in respect of the proposed activity.
vi) A member of a forest community may, together with other members or persons resident in the same area, register a community forest association under the Societies Act.

The community is expected to;

a) Protect, conserve and manage such forest or part thereof, pursuant to an approved management agreement entered into under this Act and the provisions of the management plan for the forest;
b) Formulate and implement forest programmes consistent with the traditional forest user rights of the community concerned in accordance with sustainable use criteria; and,
c) Protect sacred groves and protected trees;

The forest user rights include;

i) Collection of medicinal herbs;
ii) Harvesting of honey;

iii) Harvesting of timber or fuel wood;
iv) Grass harvesting and grazing;
v) Collection of forest produce for community based Industries;
vi) Ecotourism and recreational activities;
vii) Scientific and education activities;
viii) Plantation establishment through non-resident cultivation;
ix) Cultivation

The forests within the Lake Victoria basin constitute the main water towers in Kenya. These are the Mau and Mt Elgon forests. These forests have witnessed severe deforestation. The Forest Act needs to be invoked and strengthened to protect these vital natural resources. There is need to restore the national forest cover from the current 1.7% to at least 10%.

4.1.8. Water Act cap 372 (Water Act 2002)

The Water Act cap 372 (water Act 2002) vests the rights of all water to the state, and the power for the control of all body of water with the minister. The powers are exercised through the Minister and the Director of water resources in consultation with the water catchments boards. It aims at among others:

i) Provision for conservation of water and
ii) Apportionment and use of water resources

Water apportionment board, is a national authority whose duty is to advise the minister on issues with respect to water use. Permission to extract underground water for large-scale use lies with the Water Board and the pollution of such water source is an offence. Failure to comply with such directives is an offence. The minister is given the power to appoint undertakers of water supply that in most cases are municipal councils. The undertaker must prevent pollution of such bodies of water, failure of which is an offence.

Further in order to provide security and supply of water, the minister can declare catchments area of a particular source of water as protected area and restrict activities in those areas. Such orders must be publicized in the Kenya gazette.
Pollution of any water course is an offence and the act also prohibits whoever throws, conveys, cause or permits throwing of rubbish, dirt, refuse, effluent, trade waste to any body of water. It enhances the ministry's capacity to enforce the Act by reviewing the water user fees.

A large swathe of the Lake Victoria basin is occupied by water in form of Lake Victoria, rivers, and satellite lakes such as Lake Kanyaboli, Lake Sare and Lake Simbi as well as a large number of dams. For sustainable utilization of these water resources, there is need to adhere to the laid down regulations as stipulated in the Water Act.

4.1.9. The Public Health Act Cap 242 (1989)

The public Health Act borrows heavily from the common law of nuisance of the English law. Nuisance is broadly understood to mean:

i) Obstruction
ii) Smell
iii) Accumulation of waste or refuse

iv) Smokey chimneys
v) Dirty dwellings
vi) Premises used without sanitation
vii) Factories emitting smoke or smell
viii) Crowded or unkempt cemetery

The law therefore makes it an offence if the landowner or occupier allows nuisance or any other condition injurious to health in his premise. A medical officer or a public health officer aware of the existence of the danger can issue a notice for the nuisance to be removed failure of which the Medical Officer of Health can take the matter to court. The court may order the occupier to remove the nuisance or put up structures that would lead to permanent removal of the nuisance. In extreme cases the court may order that such structures be demolished completely.

The Act confers on the minister the power to make rules that are related to environmental health matters ranging from inspection of buildings and ensuring construction standards, drainage of land, layout of buildings and disposal of wastes.

The Act also empowers every local authority to make by laws with regard to the above in addition to standards like those of buildings, waste, and sanitation including effluent discharge standards from factories within its jurisdiction.

Protection of water supplies is also bestowed on local authorities that are undertakers. The act empowers the Minister of health to make rules that compel local authority to prohibit the following; bathing, washing clothes, watering animals, erection of dwellings, sanitary conveniences, stables and cattle kraals, dipping tanks, factories and other works that may pollute water supply and disposal of manure and filth or noxious offensive matter.

Environmental health is part of the duties of the local authority and they have a responsibility through Local Authority Act cap 256 to maintain sanitary services, sewerage and drainage facilities, and take measures for the control and destruction of rats, vermin etc.

In the recent past, the Lake Victoria basin has witnessed increased outbreaks of water borne and water related diseases such as Diarrhoea, cholera and dysentery. The various establishments that deal in foods and sanitation must adhere to the laid down regulations as stipulated in the Public Health Act in order to minimize disease outbreaks and enhance sanitary standards.

4.1.10. The Penal Code

The Penal Code, CAP 63 enacted in 1930 contains a section entitled 'offences against health and convenience'. It prohibits the fouling of air by industries and manufacturers. It is expected that the project will take every measure to ensure that no foul air is emitted into the atmosphere.

With the increasing number of industries within the Lake Victoria basin such as sugar, agrochemical and mining, the Penal code and the EMCA (1999) are the

current acts that regulate the quality of the discharge. Companies within the basin have to comply with the set standards by the above named Acts and any other Acts that come to force in a bid to set standards.

4.1.11 The Chiefs Authority Act

The Chiefs Authority Act, CAP 128 is as old as the Kenya colony. Principally, the colonial government for the maintenance of law and order enacted it. The Chief has wide powers such as controlling the cutting of timber, controlling the grassfires and prohibiting pollution of waters.

The chiefs Act complements the EMCA (1999) and any other relevant Act to regulate and restrict the misuse and destruction of the Environment.

4.1.12. The Radiation Protection Act

The Radiation Protection Act (CAP 243) regulates the importation, exportation, use and disposal of materials capable of producing ionizing radiation.

The Lake Victoria basin is dotted with many industries in manufacturing and processing sectors. The workers are protected by the Radiation Protection Act from any harmful rays. The factories must adhere to the laid down regulations under the Act.

4.1.13. The Local Government Act

The Local Government Act, CAP 265, enacted in 1963, gives the Local authorities wide-ranging powers to undertake tree planting, garbage collection, provision of clean water and effective sewage system.

This Act empowers the Municipal Authority to provide and maintain sanitation and sewerage services and to take measures to control or prohibit factories and industries from emitting smoke, fumes, chemicals, gases, dust, smell, noise, vibrations or any danger, discomfort or annoyance to the neighbourhood and to control disinfections particularly using cyanide. They are empowered to punish those disrupting sanitation or sewerage lines and can compel owners to construct sewage line into the systems and drainages.

Increased urbanization within the Lake Victoria basin is stressing the available land. Slum development does not take into consideration the resultant waste generated. There is need to adhere to the local government Act. Particularly, there is need to undertake the repair of the wastewater treatment facilities in Kisumu and Homabay to reduce the discharge of untreated waste.

4.1.14. Land Tenure and Land Use Legislation

The Kenyan Constitution, which is the basic law of the land, provides for protection of private property from deprivation without lawful compensation. The constitution also provides that such property may be “acquired if it is necessary in the interest of defence, public security, public morality, etc”. Land is a crucial national resource that is basic to the livelihood and well being of Kenyans.

The Act is very important to protect against unsuitable land use practices that could affect the sustainability of land and water resources. It also helps to avoid

conflicts in the use of land resources among competing parties. An example in the lake basin is in the Yala Swamp where there have been conflicts between the Dominion Farms Ltd. and local communities about the use or conservation of Yala Wetland.

The following are some of the main statutes that regulate land ownership and land use in Kenya.

4.1.15. The Government Lands Act, Cap. 280

Under this act, the President through the Commissioner of Lands may allocate any unalienated land to any person he so wishes. Once allocated, such land is held as a grant from the government on payment of such rents as the government may announce. The government may call back the land at any time for its own use. The act covers agricultural land and town plots within local authorities, which are allocated on application by interested persons. Such land is held for a maximum period of ninety-nine years, subject to renewal. Such allocations have often disregarded social and environmental imperatives, leading to degradation, inequity and other undesirable impacts.

4.1.16. The Registered Land Act, Cap. 300

Under this Act, any person may acquire absolute ownership of any land once he has been registered as the absolute owner. On registration, such a person acquires freehold interests on the land. A subsequent buyer of the same land acquires the same rights as enjoyed by the previous owner.

4.1.17. The Trust Land Act, Cap 285

The constitution vests all land which is not registered under any act of Parliament under the ownership of local authorities as Trust Land. Under the Act, a person may acquire leasehold interest for a specific number of years subject to renewals. The local authorities retain the powers to repossess such land for their own use should the need arise.

4.1.18. The Land Acquisition Act, Cap. 295

This Act gives powers to the government to acquire any person's land for public utilities. The act however stipulates that once such land is acquired, prompt and full compensation should be paid to the owner. The government determines the level and mode of such compensation.

4.1.19. Physical Planning Act, Cap 286

The Act provides for the preparation and implementation of physical development plans for connected purposes. Under the Act, Local Authorities prohibit or control the use and development of land; consider and approve all development applications and grant development permission; and ensure the proper execution and implementation of approved physical development plans. The act requires that Environmental Impact Assessment (EIA) report be submitted with proposals for industrial location, dumping sites, sewerage treatment, quarries or any other developments likely to cause injurious environmental impacts. The Act further prohibits other licensing authorities from granting a license for commercial or industrial use to developments not permitted by the respective Local Authority.

4.1.20. Land Planning Act, Cap. 303

The operative clauses of this act are contained in the Development and Use of Land (Planning) Regulations, which provide that land be dealt with either under an area plan or a town plan, superintended by an interim planning authority. Under this Act, all developments or any form of land use in the designated areas are subject to approval by the interim planning authority or the Central Authority (the overall governing body under the Act) in the absence of an interim planning authority. The Central Authority decides instances when the proposal is to be referred to the relevant Local Authority. Any change of use or actual development without authority is prohibited. Similarly, deposition of refuse, scrap or waste materials in a designated area without the consent of the planning authority or the relevant local authority is prohibited under this Act.

4.1.21. The Mining Act Cap 306

The current legislation on minerals in Kenya is contained in The Mining Act Cap 306 (1940) Laws of Kenya and The Trading in Unwrought Precious Metals Ordinance Cap 309 (1940). This act completely excludes provisions for artisan mining of mineral resources in the country and needs to be overhauled.

4.1.22. Food and Poisons Act

The food and poisons act guards against the production and distribution of foodstuff or food compliments that may have deleterious effects to human and other consumers. The Act is very clear on the poisons that are deleterious. Of particular importance is the use of poisons in fishing which is forbidden and illegal.

4.2. Relevant Government Sessional Papers

There are a number of sessional papers prepared by the Government of Kenya that are applicable to the Lake Victoria basin.

4.2.1. The Sessional Paper No 1 of 1999

The Sessional Paper No 1 of 1999 on National Policy on Water Resources Management and Development protects available water resources from pollution. It provides for strict stream effluent discharge standards. It also makes water abstraction and disposal permits dynamic and provides for economic instruments for water pollution control.

It provides a process of quality monitoring of all water bodies and pollution control inspection of potential polluting sources to be put in place. It controls the discharge of undesirable substances in the water system, unless prior authority has been sought from the relevant authorized agency. In this regard, levies on inefficient discharges are proposed.

4.2.2. Sessional Paper No. 1 of 2002

Sessional paper No. 1 of 2002 on National Population Policy for Sustainable Development which is an update of Sessional Paper No. 4 of 1984 on Population Policy Guidelines addresses issues on environment, gender, poverty and problems faced by segments of the population including the youth, the elderly

and persons with disabilities. Outlined in the paper are population and development goals and objectives including improvement on standards of living and quality of life of the people, full integration of population concerns into development process, motivating and encouraging Kenyans to adhere to responsible parenthood, and empowerment of women. The problem of HIV/AIDS is also addressed.

The two sessional papers recognize the need to protect the waters of Lake Victoria from pollution. The effluent discharge standards are emphasized and should be enforced by the EMCA (1999) and NEMA which is the legally mandated body on protection of the environment.

4.2.3. The Poverty Reduction Strategy Paper

The Poverty Reduction Strategy Paper (PRSP) outlines the priorities and measure necessary for poverty reduction and economic growth. The objectives of economic growth and poverty reduction are borne out of realization that economic growth is not a sufficient condition to ensure poverty reduction. In this regard, measures geared towards improved economic performance and priority actions that must be implemented to reduce the incidence of poverty among Kenyans have been identified.

The resources of Lake Victoria, which are diverse and include fish, minerals and fertile arable land, can be mobilized to reverse poverty.

4.3. International Conventions and Protocols

There are several international conventions that govern good environmental management practices such as the Ramsar Convention, Convention on International Trade on Endangered Species (CITES), Convention on Biological Diversity (CBD), etc.

In addition, there a number of international acts that provide for management and protection of the environment. These are specified in various legislations of the United Nations Environment Program (UNEP) and are complemented by several conventions.

4.3.1. Wetlands (Ramsar) convention

Wetlands are defined by convention on wetlands of International Importance especially as Waterfowl habitat (RAMSAR 1971) to which Kenya is party. The RAMSAR definition states that wetlands are "*areas of land that are permanently or occasionally water-logged with fresh, saline, brackish or marine water, including both natural and man-made area that support characteristic biota*". Kenya ratified the Ramsar convention in the 1990. Parties to the convention are expected to promote the wise use of wetlands in their countries and to put in place conservation measures by establishing nature reserves in wetlands, whether they are included in the Ramsar list or not.

The Kenya Government is a signatory to this convention. The Lake Victoria basin is dotted with some of the largest wetlands such as Yala Swamp, which need to be considered as Ramser sites to enforce their protection from developers. Some

of the Lake Victoria wetlands harbour endangered species such as the papyrus warbler *and the* Sitatunga Tragelaphus spekeii

4.3.2. FAO Code of Conduct for Responsible Fisheries

The Code of Conduct for Responsible Fisheries, published in 1995, is the most important 'soft law' for fisheries management and development. Guidelines for its implementation include:

i) No.1. Fishing operations
ii) No.1, Suppl.1. Fishing operations and vessel monitoring system
iii) No.2. Precautionary approach to capture fisheries and species introductions
iv) No.3. Integration of fisheries into coastal area management
v) No.4. Fisheries management
vi) No.4, Suppl.1. Conservation and management of sharks
vii) No. 5. Aquaculture development
viii) No.6. Inland fisheries
ix) No.7. Responsible fish utilization
x) No.8. Indicators for sustainable development of marine fisheries.

Guideline No.7 on 'Responsible fish utilization' gives important orientations to fisheries managers and fish technologists on responsible utilization of catches and resources for optimal nutritional and socio-economic benefit for both producers and consumers.

Kenya is a signatory to this Code and adheres to the guidelines stipulated in this Code in Lake Victoria. The Fisheries Department enforces the code of conduct for responsible fisheries. Regional bodies such as the LVFO also stress on the guidelines on the whole lake to cover the other riparian countries.

4.3.3. FAO Code of Conduct for Use of Pesticides

In 1985, the Food and Agriculture Organization (FAO) of the United Nations adopted the International Code of Conduct on the Distribution and Use of Pesticides. The objectives of the FAO Code are to set forth responsibilities and establish voluntary standards of conduct for all public and private actors engaged in or affecting the distribution and use of pesticides. In particular the Code aims at situations where there is no national law or only an inadequate law to regulate pesticides. The most recent revision was in November 2002. Its Specific aims are:

i) to promote Good Agricultural Practice, thus ensuring efficient and safe use while minimizing health and environmental concern;
ii) to establish responsible and generally acceptable trade practices;
iii) to assist countries which have not established controls designed to regulate the quality and suitability of pesticide products needed in that country; and,
iv) to ensure that pesticides are used effectively for the improvement of agricultural production and of human, animal and plant health.

The code also includes a section on Prior Informed Consent (PIC), a legally binding convention that enables governments to restrict import of certain banned and severely restricted hazardous pesticides.

This convention has a lot of relevance to Lake Victoria basin, considering the large amount of agricultural chemical load that is released into the water system and eventually to the lake. The convention promotes good conduct in the use of pesticides which, if followed, may help control pesticides finding way in the food chain.

4.3.4. The Kyoto Protocol

United Nations Framework Convention on Climate Change (UNFCCC), whose membership is 189 countries around the world, have joined an international treaty that sets general goals and rules for confronting climate change. The Convention has the goal of preventing "dangerous" human interference with the climate system. The functioning of the Convention depends on a series of groups and agencies which operate at the centre of a lively debate. Under the Rio Conventions climate-change treaty was one of three adopted at the 1992 Rio Earth Summit. The others were the Convention on Biological Diversity and the Convention to Combat Desertification, which involve matters strongly affected by climate change. Attempts are being made to coordinate the work of the three agreements.

Kenya is a signatory to the Kyoto Protocol. The Lake Victoria wetlands are considered as major sinks of carbon. The major forests like the Mau and Mt Elgon
within the catchment can be regenerated and used to trade in carbon.

4.3.5. Montreal Protocol

The Protocol was signed in 1987 and substantially amended in 1990 and 1992. The Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere, such as chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform, are to be phased out by 2000 (and 2005 for methyl chloroform). Scientific theory and evidence suggest that once emitted to the atmosphere, these compounds could significantly deplete the stratospheric ozone layer that shields the planet from damaging UV radiation. The Vienna Convention for the Protection of the Ozone Layer (1985), which outlines states' responsibilities for protecting human health and the environment against the adverse effects of ozone depletion, established the framework under which the Montreal Protocol was negotiated.

The Biomass burning of vegetation and the subsequent release of gases that are ozone depleting is rampant in the Lake Victoria basin. The use of gadgets such as fridges using fluorine is still rampant in the Lake Victoria. Measures should be put in place to enforce the guidelines to reduce the production of ozone depleting substances in the Lake Victoria basin.

4.3.6. Bonn Convention for the Protection of Migratory Species of Wild Animals

The convention came into force in November 1983 and its fundamental target is the protection of the migratory species (not only birds but also mammals, fish and molluscs etc.), recognizing the fact that these species need protection in every

part of their migration route and their protection requires international cooperation and action. The Bonn Convention provides for three basic actions for the protection of the migratory species of wild fauna (as described in article ii):

i) The contracting members must promote, coordinate and support research regarding the migratory species.
ii) The contracting members must provide immediate protection for the migratory species included in Appendix I of the Convention.
iii) The contracting members must come into agreements for the protection and management of the migratory species mentioned in Appendix II of the Convention.

Certain bird species that are globally threatened and occur in Europe are included in Appendix I of the protocol. Some of the crossover states for those species which have signed the Convention are; Hungary, Germany, Norway and Sweden for the White-tailed Eagle *Haliaaetus albicilla*; and Italy, Spain for the Audouin's Gull *Larus audouinii.*

4.3.7. Cartagena Protocol on Biosafety to Convention on Biological Diversity

The Convention on Biological Diversity (1992) entered into force on 29th December 1993. It addresses biodiversity issues and comprehensive and holistic approach to the conservation of biological diversity, the sustainable use of natural resources and the fair and equitable sharing of benefits deriving from the use of genetic resources. Biosafety is one of the issues addressed by the Convention. This concept refers to the need to protect human health and the environment from the possible adverse effects of the products of modern biotechnology. At the same time, modern biotechnology is recognized as having a great potential for the promotion of human well-being, particularly in meeting critical needs for food, agriculture and health care.

The Protocol thus creates an enabling environment for the environmentally sound application of biotechnology, making it possible to derive maximum benefit from the potential that biotechnology has to offer, while minimizing the possible risks to the environment and to human health.

4.3.8. Convention on International Trade in Endangered Species

The Convention on International Trade in Endangered Species of Wild Fauna and Flora, more commonly known as CITES, aims to protect certain plants and animals by regulating and monitoring their international trade to prevent it reaching unsustainable levels. The Convention entered into force in 1975. CITES regulates international trade in over 30,000 species, of which approximately 25,000 are plants. These species are listed in three appendices of the convention document categories. Proposals to amend the appendices, and new resolutions on the implementation of the convention, are considered at the biennial Conference of the Parties (COP).

Currently, over 2,500 animal and 25,000 plant species are included in the Appendices of CITES. Not all the species are exotic – some are native to the UK and other parts of Europe. The species included in Appendices I and II, and other matters relating to the implementation of CITES, are discussed at the biennial

Conference of the Parties (COP) to CITES. Proposals to amend the Appendices are put forward by Parties to the Conference.

The different Appendices are as follows: Appendix I includes species that may be threatened with extinction and which are or may be affected by international trade. International trade in wild specimens of these species is subject to strict regulation and is normally only permitted in exceptional circumstances. Trade in artificially propagated or captive-bred specimens is allowed, subject to license. Over 800 species are included in Appendix I at present, including tigers, great apes, certain parrots and certain species of orchids and cacti. Appendix II includes species not considered to be under the same threat as those in Appendix I, but which may become so if trade is not regulated. International trade in these species is monitored through a licensing system to ensure that trade can be sustained without detriment to wild populations.

Trade in wild, captive bred and artificially propagated specimens is allowed, subject to permit. Approximately 29,000 different species are included in Appendix II, including polar bears, Asiatic cobras, orchids, cacti and carnivorous plants. Appendix III contains species that are not necessarily threatened on a global level, but that are protected within individual states where that state has sought the help of other CITES Parties to control international trade in that species. Examples include the Bengal fox from India, the Neotropical rattle snake from Honduras, and mahogany from Brazil, Costa Rica, Mexico and Bolivia and the Basking shark from the UK.

The Lake Victoria basin is home to the two major national parks in Kenya namely Masai Mara and Ruma national park. The animals like Elephants, which are in category II are well protected by this convention. Perhaps it would be prudent to consider the endangered Sitatunga Tragelaphus spekeii *for elevation to category to prevent its disappearance.*

4.3.9. Agreement Related to Conservation of Highly Migratory Species

The convention on migratory species (CMS) was adopted to conserve migratory species of wild animals given that migratory species are seen as an international resource. Such species may be terrestrial or marine. The conventions agreement on the conservation of African-Eurasian Migratory water birds is specific on the need to protect the feeding, breeding and wintering habitats, the main ones being wetlands and open water bodies. Kenya observes the convention.

4.3.10. World Heritage Convention

The Convention for World Heritage came into force in December 1975 and its target is the protection of the cultural and natural heritage having exceptional world value. According to the Convention, the following can be regarded as "natural heritage" (Article 2):

i) Natural monuments consisting of natural or biological formations or groups of such formations, having exceptional aesthetic or scientific world value.
ii) Geological and physiographical formations and accurately delimited areas which are habitats of threatened animal and plant species of

world value in terms of science or the need for the conservation of the species.

iii) Natural landscapes or accurately delimited areas of exceptional world value in terms of science, and the need for conservation or the natural beauty.

Article 4 of the Convention points out that every contracting member recognized the obligation to ensure the delimitation, protection, conservation and tradition to the future generations of the natural heritage located in its territory. Article 4 demands for every contracting member to do whatever possible for the achievement of these goals. Every contracting member identifies areas of natural heritage according to article 2 and is obliged to, in the extent possible, submit to the World Heritage Committee an inventory of the cultural and natural heritage goods located in its territory and fill the prerequisites for their inclusion on the catalog of article 11. The referred catalog is the World Heritage Catalog, and the World Heritage Committee is responsible for it. The contracting members of the Convention accept the legal responsibility to do whatever they can in order to protect the areas of the catalog.

The Lake Victoria basin has some of the most beautiful cultural sites such as Simbi Nyaima, Thim Lich Ohinga and the weeping stones of Kakamega and Seme. These are important sites and need to be conserved within the convention.

4.3.11. United Nations Convention on Biological Diversity

The convention was made in Nairobi in 1992, of which Kenya is a signatory. The approach of conservation of biodiversity is basically broad. Parties to the convention are required to adopt national strategies, plans and programmes for the conservation and sustainable use of biological diversity into their relevant sectoral and cross-sectional plans, programmes and policies.

4.3.12. Convention to Combat Desertification

The United Nations Convention to combat desertification in those countries experiencing serious drought and/or desertification, particularly in Africa. The Convention's full name, was adopted on 17 June 1994 and opened for signature in Paris in October that year. As at 14 January 1997, the Convention had been ratified by 60 countries. It entered into force on 26th December 1996.

The Convention calls for action involving international cooperation and a partnership approach. It focuses on improving land productivity, rehabilitation of land, conservation and sustainable management of land and water resources. Such action should also prevent the long-term consequences of desertification, including mass migration, species loss, climate change and the need for emergency assistance to populations in crisis. The Convention establishes a framework for national, sub regional and regional programmes to counter the degradation of drylands, including semi-arid grasslands and deserts. It calls on developed countries to:

i) Actively support the efforts of affected developing country parties to the Convention;

ii) Provide "substantial financial resources" to assist affected developing country parties;
iii) Promote the mobilization of adequate, timely, and predictable financial resources from all official and private sources; and
iv) Promote and facilitate access to appropriate technology, knowledge and know-how.

Desertification-affected countries are obliged to:

i) Give priority to combating desertification and drought by allocating adequate resources in accordance with capabilities;
ii) Establish strategies to combat desertification and drought;
iii) Address the underlying causes of the problem and pay special attention to relevant socio-economic factors;
iv) Promote awareness and the participation of local population in action to combat desertification and drought; and
v) Provide an enabling environment through appropriate laws, policies and action programmes.

4.3.13. Convention on the Conservation of Migratory Species

The convention on migratory species (CMS) was adopted to conserve migratory species of wild animals given that migratory species are seen as an international resource. Such species may be terrestrial or marine. The conventions agreement on the conservation of African-Eurasian Migratory water birds is specific on the need to protect the feeding, breeding and wintering habitats, the main ones being wetlands and open water bodies. Kenya observes the convention. The Lake Victoria region has five out of the sixty sites that have been identified as Important Bird Areas (IBAs) of Kenya. Nature Kenya, Birdlife international and Global Environment Facility (GEF) have identified the sites. The program is a worldwide initiative working for the conservation of biological diversity and sustainability of human use of natural resources. The project is expected to recognize these sites and protect them where they occur in the project area or its environs.

The Lake Victoria basin is dotted with wetlands, which are the major flyways and fueling stops for the migratory birds. Of concern is the recent outbreak of Bird Flu associated with migratory birds. Efforts should be directed to halting destruction of the wetlands that are in the migratory routes for the birds as well as measures to prevent the escalation of the bird flu. The wetlands are famous for their bird diversity. Bird distribution is influenced by human activities, availability of food and seasons. Bird species that are endemic to papyrus swamps include vulnerable Papyrus yellow warbler Chloropeta gracilirostris*, the endangered* Papyrus Gonolek*,* Laniarius mufumbiri *the Papyrus Canary* Serinus koliensis*, Carruthers's Cisticola,* Cisticola carruthersi *and white-winged warbler* Bradypterus carpalis*. These birds are contained in the East African Red Data list of birds.*

4.3.14. Singapore Treaty on the Law of Trademarks

The treaty provides for industrial countries to provide the technical assistance and other forms of support that a country needs to strengthen institutions that will enable it to take full economic advantage of trademarks. The treaty provides the

framework for procedural aspects of trademark registration and licensing that ensures benefits accrue to brand owners while facilitating greater flexibility and efficiency in trade registration services. The treaty eliminates the obligation of contracting parties to implement electronic filing systems. The treaty affirms the importance of trademarks as a key component of intellectual property.

The streamlining of trademark registration would help promote domestic and international trade as well as enhance enterprise development and consumer confidence. Common standards on the procedural aspects of trademark registration and licensing member states are expected to create a level of playing field for those who invest in branded goods. The treaty has a built in review mechanism for administrative details that are of lesser order but of practical importance to brand owners. It recognizes developments in branded goods industry and establishes a new approach to securing investment in product differentiation. The treaty takes into account the advantages and potential of electronic communication facilities while recognizing the varying needs of developing and developed nations.

4.3.15. United Nations Convention on Climate Change (UNFCC)

This explicitly charges developed countries with assisting 'the developing country parties" that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects.

4.3.16. Hazard Analysis Critical Control Point (HACCP)

Hazard Analysis Critical Control Point (HACCP) is a preventative system of hazard control rather than one of reaction or point inspection to decrease a hazard. Food processors can use HACCP to identify hazards, establish controls and monitor the controls in the case of harmful microorganisms or chemical and/or physical contaminants in food. The United States Food and Drug Administration (FDA) first required HACCP control for food processing in 1973 for canned foods to protect against *Clostridium botulinum*, and recently has been required for seafood in the United States. HACCP has also been endorsed worldwide by Codex Alimentarius, the European Union, and by several countries including Canada, Australia, New Zealand and Japan.

The first detailed publication in the United States of how HACCP could be applied to the seafood industry appeared in 1977, and except for low acid canned food, few attempts were made before 1985 to apply HACCP to seafood products. The FAO Fish Utilization and Marketing Service began in 1985 to use HACCP in its training programmes and the United States National Marine Fisheries Service (NMFS) developed a HACCP based programme for seafood. The European Union formally shifted to the preventative systematic approach provided by HACCP in 1991 (EEC Commission Decision, 1991b). The main technical characteristic of the new inspection and quality control procedures approved at that time was the adoption and enforcement of HACCP in European Union member countries and in those countries that wish to export to the European Union (Lima dos Santos *et al*., 1993). HACCP is based on the following seven principles;

a) Conduct hazard analysis and identify preventative measures;
b) Identify critical control points (CCP);

c) Establish critical limits;
d) Monitor each CCP;
e) Establish corrective action to be undertaken when a critical limit deviation occurs;
f) Establish verification procedures; and,
g) Establish a record keeping system.

4.4. Panafrican Initiatives

4.4.1. New Economic Partnership for African Development (NEPAD)

This is a comprehensive African agricultural development program that emphasizes investment in sustainable land management.

4.4.2. The TerrAfrica Partnership

This is an NGO formed in October 2005 and aims at helping increase agricultural productivity in the Lake Victoria basin by 6% per year. It also aims at looking at the root causes of land degradation.

4.4.3. The Nile Basin Initiative

The Nile Basin Initiative (NBI) is a regional project whose vision is to harness the resources of the River Nile to fight poverty. The countries comprising the NBI are Kenya, Uganda, Tanzania, Burundi, Eritrea, Congo, Rwanda, Egypt, Ethiopia and Sudan. In the Trans Mara region, the project is addressing the poor agriculture practices, destruction of the wetlands, and lack of adequate human and institutional capacities. The agricultural program, which is hosted by Kenya, aims at improving food production through harnessing the Nile waters. The issues addressed include water harvesting, community managed irrigation as well as privately managed irrigation.

The initiative also aims to help develop sustainably managed technologies for rain fed crop production and increased water supplies for small scale irrigation and household water needs. The Lake Victoria basin will also benefit under this project from the power trade project. The project is aimed at developing the hydroelectric power potential of the River Nile as well as build power arteries in the NBI member states. The Sio–Malaba-Malakisi and the Kagera river basins have been targeted for this. The project will also foster and improve tourism and environmental protection.

4.4.4. Nile Equatorial Lakes Subsidiary Action Programme (NELSAP)

Three river basin integrated water resources management projects covering the Kagera, the Mara and Sio-Malaba-Malakisi River basins are being implemented under the auspices of the Nile Basin Initiative/ Nile- Equatorial Lakes Subsidiary Action Programme (NELSAP). The first phase of these projects, was completed in February 2004. In March 2005 financing agreements between SIDA and NBI were signed and implementation of the projects is now on-going. The EAC-LVDP provides the requisite political support to the implementation of these projects.

4.4.5. Mount Elgon Regional Ecosystem Conservation Programme (MERECP)

This programme aims at ensuring that biodiversity ecological functions and the intrinsic values of the transboundary ecosystem are conserved for present and future generations as well as the global community. The inception phase of this

programme, which commenced in February 2004, was concluded in March 2005. The Royal Norwegian Government provided the technical back-sopping to this phase while the EAC Secretariat will be responsible for the overall coordination. Uganda Wildlife Authority, and districts of Mbale, Sironko and Kapchorwa in Uganda and the Kenya Wildlife service Forest Department as well as the districts of Trans Nzoia, and Mt. Elgon in Kenya are the partner implementing institutions for this programme.

4.4.6. Transboundary Environmental Impact Assesment (EIA) Guidelines

This project developed a body of Guidelines for the proper Conduct of regional Environmental Impact Assessment of shared ecosystems of East Africa. The Lake Victoria is one of such ecosystems and the largest as well. The project was funded by USAID/REDSO with technical coordination provided by the African Center for Technology Studies (ACTS). The project was completed in 2004.

4.5. East African Community Protocols, Programs and Projects

Several regional Programmes and Projects are being implemented under the auspices of the East African Community. The EAC has also put in place a number of protocols relevant to its key objectives. They include the following:

4.5.1. EAC Partnership Agreement

The EAC Secretariat, recognizing the role played by other stakeholders in the developments in the Lake Victoria basin, entered into partnerships and signed Agreements with governments and institutions so as to build up synergies in the implementation of EAC strategy by the stakeholders. Notable among these are:

a) Partnership Agreements on Sustainable Development of Lake Victoria basin signed by EAC with the Governments of France, Norway and Sweden, the World Bank and the East African Development Bank in April 2001. The partnership Fund, established under the partnership Agreement has played a major role in financing Projects developed under LVDP including, "Capacity building of the Lake Development Programme Unit".

b) The EAC Secretariat signed Memoranda of Understanding with the following Institutions and Governments: World Conservation Union (IUCN) Regional office on 28th June; World Wildlife Fund for Nature – Eastern Africa Regional Programme Office (WWF – EAPRO) on 4th August 2003; International Center for Research in Agroforestry (ICRAF) on 26th September 2003; and the governments of the Republics of Rwanda and Burundi in 2004.

4.5.2. Lake Victoria Environmental Management Project (LVEMP)

The Project was implemented under Tripartite Agreement signed by the three partner states of Kenya, Tanzania and Uganda in 1994 before the signing of the EAC Treaty in 1999. It was financed from World Bank and Global Environment Facility. This project has been the biggest undertaking in the Lake Victoria basin and was mostly implemented by personnel from the three Partner state. The first phase was completed in December 2005. The second phase of LVEMP is now under preparation and is being coordinated by the EAC Secretariat.

4.5.3. Safety of Navigation on Lake Victoria Project

The French Government funded this project whcich was implemented and coordinated by the International Maritime Organization (IMO). In November 2001 a contract was signed under which funding was provided for the short the short-term consultancy assignments. Between 2002 and 2003, with technical support from IMO, the planned project activities on maritime legislation (drafting of legislation and regulation), aids to navigation, search and rescue and hydrography were implemented. The studies have been completed with major recommendation to create a single authority to oversee the Safety of Navigation on Lake Victoria. The EAC Council of Ministers at its meeting in January 2004 approved the creation of such a body but within the Lake Victoria basin Commission (LVBC). Other outputs include a draft Lake Victoria transport Bill 2003 which is awaiting approval by the EAC Sectoral Council.

On 21 April 2004, the government of France and the EAC Secretariat signed a Financing Agreement to support the formulation of new legislative and regulatory framework for Lake Victoria. The EAC Secretariat will solicit for additional funding to finance the other project components such as aids to navigation and hydrographic survey. The Department for International Development (DFID) of the United Kingdom donated a research vessel to the EAC, which will be used for research, survey and other activities on Lake Victoria.

4.5.4. Communication Strategy for Lake Victoria Basin

This project was initiated in 2003, with the aim of addressing the communications needs for support to the Lake Victoria basin development. The project components include: telecommunication infrastructure, information and mass media. The project is part of EAC Communication Strategy. The Partnership Consultative Committee identified the need to fast track the component. The project's preliminary study report of June 2003 recommended the establishment of a regional carrier telecommunications company as a high priority for providing transport network capacity between the three partner states and to substantially improve interregional telecommunications in the region. The network could be implemented using extended GSM technology, which would use the normal cell phones. A pre-feasibility study for the proposed carrier company was undertaken between November 2003 and February 2004. It indicated that the proposed company was economically feasible.

4.5.5. Lake Victoria Fisheries Organization (LVFO)

The Convention establishing the Lake Victoria Fisheries Organization (LVFO) was signed on 13th June 1994 by the three partner states i.e. Kenya, Uganda and Tanzania. The main objective of the LVFO is to foster cooperation among the contracting parties, harmonise national measures for sustainable utilization of the living resources of the Lake and to develop and adopt conservation and management measures.

4.5.6. Shared Vision and Strategy Framework for Lake Victoria Basin

The EAC secretariat and the three partner states developed a vision and a strategy framework for the management and development of Lake Victoria basin. The process involved extensive consultations across a wide range of

stakeholders, starting from the local communities up to the national and eventually to regional levels. The civil society and private sector organizations were also involved both at national and regional levels. The 7th EAC Council of Ministers meeting held in January 2004 adopted the vision report and further directed that it should be used as a planning tool by all stakeholders operating in the Lake Victoria basin.

4.5.7. Lake Victoria Basin Economic Potential and Constraints

The East African Community secretariat commissioned a study to fully assess the potential and constraints of developing the Lake Victoria basin as an economic growth zone, with a view to stimulating economic growth in the region following the designation of the region as an economic growth zone. The study was completed in December 2003. The report detailed the stock of the available resources, the opportunities, constraints and limitations in exploiting the potentials, and the required strategies to stimulate sustained economic growth.

4.5.8. Lake Victoria Basin Commission (LVBC)

The Lake Victoria Basin Commission (LVBC) is established by the protocol for sustainable development of Lake Victoria basin, under article 33, as a permanent apex institution of the EAC responsible for the lake basin. The objectives and broad functions of the commission are also defined in this article. Article 42 of the protocol defines the functions of the secretariat of the commission. The signing of the protocol on 29th November 2003 and its ratification in December 2004, in effect, cleared the way for the establishment of LVBC. The signing of the protocol alone was a clear manifestation of the determination of the EAC to set up an institution to manage the Lake Victoria basin. This manifestation was reaffirmed when the three Partner States ratified the protocol.

The commission started its operation in July 2004 and was formally launched in July 2005. Initially the secretariat has been operating from the EAC headquarters in Arusha, but will be moving to its permanent secretariat headquarters in Kisumu City, Kenya. The EAC Council of Ministers allocates funds for the commission to meet recurrent, administrative and financial costs as well as development and capital expenditure. Evidently, this is a clear sign of commitment by the partner states on the operationalisation of LVBC.

4.5.9. East African Community Protocol for the Sustainable Development of Lake Victoria Basin

The protocol for the sustainable development of Lake Victoria basin was signed on the 29th November 2003. The protocol is based on the fact that the three partner states enjoy close historical, commercial, industrial, cultural and other ties and are also signatories of the East African Community treaty. The states recognize the need for increased investiments in the fields of energy, transport, communications, infrastructure, tourism, agriculture, fisheries, livestock, forestry and mining. In addition, the treaty reconizes that development activities may have negative impacts on the environment leading to degradation of the environment and depletion of natural resources. It also recognizes the fact that that a clean and healthy environment is prerequisite for the sustainable development of the basin. The document empahsizes that to sustain life, development and environment must be managed in an integrated and holistic manner which link

social and economic development with protection and conservation of the natural resources.

4.5.10. East African Community Protocol on Environment and Natural Resources Management

The protocol came into force on 3rd April, 2006. The protocal emanates from the convention for the establishment of the Lake Victoria Fisheries Organization (LVFO) signed on 30th June 1994. Chapter 19 and 20 of this convention provides for cooperation on environment and natural resources management. The protocol emphasizes that a clean and healthy environment is a prerequisite for sustainable development. The riparian states recognize that development activities may have adverse impacts on the environment leading to degradation of the environment and depletion of the natural resources. The partner states have affirmed to take measures to control the environment and natural resources degradation and to achieve sustainable development for the benefit of the present and future generations. The states emphasize the need to take measures to control environment and natural resources degradation especially air, land and water pollution arising from transboundary activities. In addition, the states empahsize the need to adopt a common vision in addressing the challenges of achieving sustainable development at the local, national and regional levels through sound environment and natural resources management.

4.6. The Millennium Development Goals (MDGs)

The Millenium Development Goals present a commitment by United Nations Member States to achieve certain specific measurable development targets within specified time frame. The main development targets are to;

1) Eradicate extreme poverty and hunger

- Reduce by half the proportion of people living on less than a dollar a day, and the proportion of people who suffer from hunger

2) *Achieve universal primary education*

- Ensure that all boys and girls complete a full course of primary schooling.

3) *Promote gender equality and empower women*

- Eliminate gender disparity in primary and secondary education preferably by 2005, and at all levels by 2015.

4) Reduce child mortality

- Reduce by two thirds the mortality rate among children under five.

5) *Improve maternal health*

- Reduce by three quarters the maternal mortality ratio.

6) Combat HIV/AIDS, malaria and other diseases

- Halt and begin to reverse the spread of HIV/AIDS, and the incidence of malaria and other major diseases.

7) *Ensure environmental sustainability*

- Integrate the principals of sustainable development into country policies and programme and reverse loss of environmental resources.
- Reduce by half the proportion of people without sustainable access to safe drinking water.
- Achieve significant improvement in lives of at least 100 million slum dwellers by 2020.

8) Develop a global partnership for development

- Develop further an open trading financial system that is rule-based, predictable and non-discriminatory. This includes a commitment to good governance, development and poverty reduction nationally and internationally.
- Address the least developed countries' special needs. This includes tariff and quota-free access for their exports, enhanced debt relief for heavily indebted poor countries, cancellation of official bilateral debt, and more generous official development assistance for countries committed to poverty reduction.
- Address the special needs of landlocked and small island developing states
- Deal comprehensively with developing countries' debt problems through national and international measures to make debt sustainable in the long run.
- In cooperation with the developing countries, develop decent and productive work for the youth.
- In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries.
- In cooperation with the private sector, make available the benefits of new technologies – especially information and communications technologies.

The Lake Victoria basin has adopted measures to meet the MDGs. The basin has embarked on projects such as rainwater harvesting especially in areas of conservation agriculture and for supplementary irrigation. Recently the City of Kisumu was named the Millennium City while a village at Bar Sauri in Siaya has been inaugurated as the first millennium village.

4.7 Analysis of the policy, legislative and institutional framework

A critical analysis of the various policies, legislative and institutional frameworks described above shows that certain conflicts may arise in their implementation. First, some programs have conflicting mandates. For example, LVFO, LVBC, regional development authorities (e.g. LBDA) all have institutional mandates to deal with aspects related to water resource utilization and management, however, no clear boundary is made as to what extent each institution should operate and how each should link with the other. There is need to harmonize the mandates and functions of different institutions to avoid conflicts and duplication of roles.

Secondly, various legal and regulatory frameworks have been established but due to high poverty levels, high population pressure and lack of participatory involvement, enforcement of these frameworks is inadequate. For example, the Local Government Act, EMCA Act, Public Health Act etc. all have a mandate to deal with issues of environment but no linkage is made with each other, raising conflicts in matters of enforcement. There is therefore need to institute measures to reduce poverty levels, control population growth and involve stakeholders in formulation of legislations to facilitate coordination of their enforcement.

Third, there is lack of mechanism to enforce international conventions. Various countries lack the legal framework to enforce such conventions, therefore they remain largely ineffective. For instance, countries voluntarily choose to obey the Code of Conduct for Responsible Fisheries, and there is no mechanism for legal address against those who do not observe it. Pan African Initiatives also do not have the legal framework to bind the various member states. The initiatives should have legal framework to bind the states on their implementation.

Fifth, due to lack of adequate land policies, decisions on land use are made that have important environmental implications. For instance, there are human settlements along the wildlife migration routes in Masai Mara. Certain directives are also imposed on partners states without due regard to available human, technical and financial capacity to implement the standards. One of such directive is the EU directive 91/493 and HACCP system on fish quality. Likewise, the ability to implement various EAC protocols is beyond the economic ability of the partner states.

Lack of awareness and ignorance by the stakeholders also results in non-compliance to the regulatory systems in place. For example, ignorance to the Water Act leads to cultivation along river banks/lake shores, sinking of boreholes and diverting of river courses. There is need to create awareness to the existing legal Acts.

Some legal provisions e.g. the Chief's Authority Act give excessive authority to Government agents, hence causing resentment by members of the public. Such laws should be reviewed to encompass dialogue in issues that need understanding by the communities. There is also need for clear land use policies that indicate priorities for land use. For example fertile agricultural land should be used for food production instead of settlements.

The Government has been developing very good ideas to address various issues which are presented in sessional papers, but which are never implemented. There is need for the Government to be committed to implementing policies outlined in the sessional papers. To meet the shortfall in development plans, countries resort to projects that are donor-driven, but also with donor interests, hence, are not sustainable. Projects should be in-built in the national budgetary allocation of partner states for continuity and sustainability.

SECTION 5. MAJOR TRANSBOUNDARY PERCEIVED PROBLEMS AND ISSUES

This section addresses the environmental and socio-economic issues/problems that are transboundary in nature, their extents and gaps and which must be addressed for the sustainable management in the Lake Victoria basin.

5.1. Introduction to Major Perceived Problems and Issues (MPPI)

The identification of the major perceived problems and issues (MPPI) was the main step in the TDA process and it constituted the justification for in-depth analysis. The significance of the perceived issues and problems were substantiated on the basis of scientific, environmental, economic, social and cultural grounds. This TDA, being the first and most comprehensive on Lake Victoria, aimed at identifying major perceived problems and issues associated with Lake Victoria basin. The MPPI represented the perceptions of the expert community stakeholders as given in Table 5.1. The details of the process involved identification of the facts supporting or befitting each issue as a priority in the Lake Victoria basin. The intent was to provide a technical rationale for prioritising the MPPI. This was considered important since it helped to identify major intervention efforts for each MPPI based on technical information so as to make it a priority. This approach ensured that MPPI were evaluated, prioritized, gaps identified and filled as a priority.

Listed and discussed below are major perceived problems and issues for Lake Victoria basin which have been classified as either strongly or weakly transboundary. Strongly transboundary MPPI are those that are widespread internationally and regionally, and which cut across several sectors.

Table 5.1 Major perceived problems and issues for Lake Victoria basin

MPPI	Extent
Decline in certain endemic and commercial fish stocks	Strongly transboundary
Threats to biodiversity	Strongly transboundary
Degradation of catchments landscapes and damage to catchments habitats	Strongly transboundary
Overall decline in environmental quality	Strongly transboundary
Invasive and introduced species	Strongly transboundary
Decline in human health	Weakly transboundary
Damage to catchments infrastructure and amenities	Weakly transboundary
Conflicts in resource use	Strongly transboundary
Seasonal flooding	Strongly transboundary
Lack of disaster management strategies	Weakly transboundary
Low level of adoption of appropriate technologies	Weakly transboundary

For each MPPI, the following issues were resolved

a) Knowledge of each problem/issue
b) Data support the quantification of the extent of the problem/Issue
c) Whether data supported these as real problems and issues, or just as perceptions. This in effect developed a status assessment. In addition for each MPPI a causal chain analysis was done to determine the root, primary and secondary causes through field surveys and stakeholder workshops.
d) Policy issues
e) Legal issues

The analysis recognised that productive activities take place across a number of somewhat independent sectors, for example, agriculture, industry, transport, fisheries etc., but which are usually poorly coordinated and often have conflicting interests. Sectors and their stakeholders may operate in an uncoordinated and sometimes conflicting fashion, but they typically and overally affect Lake Victoria environment in similar ways. Table 5.2 shows`the causes, impacts of MPPI for Lke Victoria basin.

Table 5.2 Causes, impacts and interventions of MPPI

Issue	Sector	Problem	Cause	Impacts	Interventions
Decline in certain endemic and commercial stocks	Fisheries	-Destruction of the fish breeding areas - threat to several aquatic species -Decline in stocks	-Overpopulation -Open access policy -Declining stocks -Lack of alternative source of livelihoods -Pollution -Over fishing -Invasion of exotic species -Human activities	-Increase in fishing effort -Overexploitation -decline in profit margin to fishers. -Decrease in Catch per Unit Effort	-Population control -Limit access to fishery -Alternative sources of livelihoods -Fish farming/ Aquaculture
Threats to Biodiversity	Fisheries	-Loss of species, genetic and habitat levels	- Overpopulation -Open access policy -Declining stocks -Lack of alternative source of livelihoods	-Imbalance in ecosystems -Loss of species -Loss of habitat for transboundary organisms-,fishes -Loss of income decline in lake productivity	-Sustainable development
	Forests	-Loss of indigenous plants	-Overpopulation -Open access policy -Declining stocks -Lack of alternative source of livelihoods	-Imbalance in ecosystems -Loss of species -Loss of habitat for transboundary organisms-	-Reafforestation -Forestry management -Alternative energy source e.g. solar, biofuels -Population control
	Wildlife	Loss of wildlife	-Overpopulation -Poaching -Declining stocks	Imbalance in ecosystems -Loss of species	-Wetland management -

Issue	Sector	Problem	Cause	Impacts	Interventions
			-Lack of alternative source of livelihoods	-Loss of habitat for transboundary organisms-birds	Reforestation -Wildlife management -Population control
Degradation of catchments, landscape and catchment habitats	Forests	Loss of vegetation	-Deforestation -Overstocking livestock	- Loss of biodiversity - Loss of fauna and flora due to damaged haitats	- Reforestation -Forest management -Modern farming practices
	Land	Loss of soil cover	-Soil erosion -Poor farming practices -Overstocking livestock	- Soil erosion -Gulleys	-Non cultivation of river banks & Lake shores -Modern farming practices
Overall decline in environmental quality	Air	Emission from factories		Decrease in human health	-Cleaner production
	Water	-Discharge of agro-chemicals into rivers/lakes -Persistent Organic Pollutants (POPs) -Biological Oxygen Demand (BOD) - High levels of faecal coliforms -Disposal of domestic and industrial wastes	-Improper use of agro-chemicals on farms -Improper runoff and drainage systems -Discharge of raw/untreated sewage into rivers/lakes	-Chronic/acute toxicity to aquatic life -Ban of fish imports from Lake Victoria - Diarreahal diseases	-Proper treatment of sewage before discharge
	Sediment	Discharge of agro-chemicals into rivers/lakes	-Improper use of agro-chemicals on farms -Improper runoff and drainage systems -Discharge of raw/untreated sewage into rivers/lakes	-Sediments may act as both sink and source of contaminants	
Invasive and introduced species	Water hyacinth infestation	-Transport hinderance -Increase in pests and diseases -Destruction of fishing gear	-Uncoordinated introductions	-Transport blockage -Destruction of fishing gear Increase in diseases and pests, snakes, mosquitoes	Proper management of the hyacinth weed
	Nile perch	-Feeding on other species	-Uncoordinated introductions	-Loss of biodiversity	-controlled introductions -
	Striga	-Reduced crop yields	-Uncontrolled introductions	-Food insecurity	-Integrated weed management

Issue	Sector	Problem	Cause	Impacts	Interventions
Decline in human and livestock health	Pests and diseases	-Increase in diseases	-Poor preventive and curative measures -Environmental factors	-High mortality and morbidity	-Preventive health management -Improved health facilities
Damage to catchments infrastructure and amenities	Land use/sedimentation	-Deforestation -Siltation -Reduced availability of water -Soil erosion	-Cutting of trees/grass for charcoal burning and logging	-During dry season, dust storms contribute to respiratory problems. -Loss of wine calabash, honey quiver, medicianal plants, lack of fuel wood/building materials. -Reducing of lake /river depths leading to decrease of fish -Food insecurity, Lack of water for livestock, sanitation	-Forestation -Soil erosion control
	Climate change	Temperature rise (global warming) -Flooding -Changing rainfall pattern -Severe droughts -Increase in severe weather events	-Emission of carbon dioxide -Deforestation	- Temperature changes affects currents, changing the migration corridors of fish -Fall in agricultural yield -Biodiversity loss due to global warming -Changes in reproductive cycles, growing seasons and frequency of pests and diseases -Affect fish stocks -Prolonged droughts, followed by extremely heavy rainfall over several days.	-Gather reliable data to assess the threat. -Help farmers to identify crops/species of fish and farming practices best suited to the new conditions
Conflicts in resource use	Livestock	Cattle rustling	-Cultural practices	-Loss of life -Economoc loss	-Sensitization -Disarmament -Alternatives dowry payments
	Fisheries	Cross-border fishing	-Unmarked boundary -Declining fish stocks	-Loss of fish -Loss of life	-mark boundaries -Co-management
	Water	Water decline	- Diversion of river course / Planting of Eucalyptus trees on common land boundary	-Drainage of water resource -Increase soil erosion and hence siltation of river beds	-Plant bamboo trees -Reconstitute river course to minimise soil erosion
	Wetland	-Wetlands	-Agricultural	-Sedimentation/siltation	- Sustainable

Issue	Sector	Problem	Cause	Impacts	Interventions
		degradation	development	-Loss of biodiversity	wetland management
	Forest	-Forest destruction	-Forest cultivation	-During dry season, dust storms contribute to respiratory problems. -Loss of wine calabash, honey quiver, medicianal plants, lack of fuel wood/building materials. -Reducing of lake /river depths leading to decrease of fish -Food insecurity, Lack of water for livestock, sanitation -Deforestation leads to strong winds, which become destructive.	- Sustainable forestry management
		-Bush fires	- Slash and burn cultivation	-Air pollution	-Good agriculture practice
	Wildlife migration	-Catchments destruction	-Lack of water/pasture	-soil erosion -Human/animal conflicts	-Fencing water source protection
Seasonal flooding	-Land -Water	-Disruption of economic activities -Destruction of infrastracture	-Lack of flood control measures -Forest destruction -Poor farming practices -Environmental factors	-Loss of life -Destruction of infrastructure	-Flood control measures e.g. dam construction -Forest management -Good agricultural practices
Disaster management	-Multi-sectoral, including land, water, forests, infrastructure,	-Disaster unpreparedness	-Poor resource allocation - Lack of early warning system - Corruption	- Loss of life - Economic loss	-Disaster preparedness / contingency plans -Put in place early warning systems
Low adoption of technology	Multi-sectoral, including; agriculture, fisheries, energy, water etc.	-Low productivity -Resource wastage -Lack of applied research	-Low incomes -Lack of training and awareness -Inappropriate technologies -Cultural impediments -Lack of incentives-financial,physical	--Low productivity -Resource wastage	-Training -Awareness creation -Appropriate technologies -Efficient technologis

5.1.1. Decline in endemic and commercial fish stocks

5.1.1.1. Statement of the problem

There is a general decline in the major commercial fish species in Lake Victoria. This includes; Nile perch, Tilappiines and Dagaa

5.1.1.2. Supporting Data

The supporting data for fisheries decline is outlined section 3.2.3

5.1.1.3. Causal chain analysis

A Causal chain analysis revealed some of the major causes for fisheries decline of the three major commercial fisheries groups, Nile Perch, Nile tilapia and Dagaa including:

i) Habitat degradation (e.g. gravel and sand harvesting, water use for agriculture, and Pollution);
ii) Lack and/or mis-management of fisheries leading towards overexploitation (e.g. no interstate agreement on fisheries management, inadequate national fishery regulation (quotas, seasons, location, size));
iii) Worsening geopolitical and economic climate causing negative impacts such as poor enforcement of and compliance with fishing regulations, open access policy thus increased fishing pressure by jobless lakeside communities.
iv) Insufficient scientific knowledge of how fish species may adapt to a changing Lake Victoria environment (e.g. new spawning grounds adopted by Tilapia due to damaged old ones by poor fishing methods such as (*Ochwado*) longer accessible).
v) Possible eutrophication effects on plankton, in some river deltas/mouths and near the urban discharges e.g Kisat River.

Figure 5.1 displays the causal chain analysis for fish stock decline.

5.1.1.4. Sectors and stakeholders

The main sectors involved in the fisheries issues are:

i) Government: ministries (e.g. environment, agriculture/fisheries, irrigation and energy (perhaps for hydropower-Sondu Miriu?), municipal, inter-government commissions and international institutions such as FAO, CITES and CBD (Convention on Biodiversity);
ii) Co-operatives; and
iii) Private sector (including non-governmental organizations).

Affected stakeholders include local fishermen, processors and traders in fish products, lakeshore residents and scientific community.
The Stakeholder analysis will show which Stakeholder Groups considers this MPPI as critical

5.1.1.5. Environmental impacts

The environmental impacts of commercial fisheries decline include a possible imbalance in the shallow deltaic and benthic ecosystems of the rivers and the pelagic ecosystems of the whole Lake Victoria.

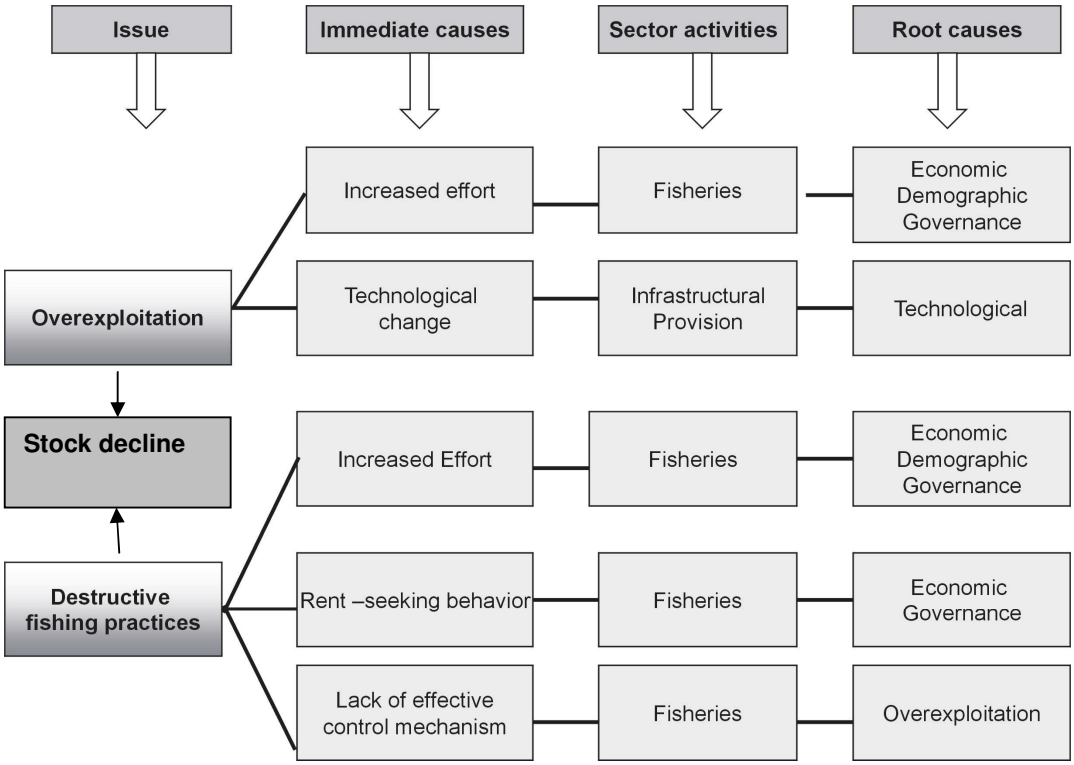


Figure 5.1 The causal chain analysis for stock decline

5.1.1.6. Socio-economic impacts

Socio-economic impacts of declining fisheries are widespread. Local fishermen are being adversely affected due to loss of livelihood and since fish can be a major part of residents' diet, a decline in health may also result. The overall fishing industry and wide range of related economic activities including fishing vessel construction and repair industries, processing industry extending as far as restaurants could be affected by reduced fish stocks. Artificially high prices for Nile Perch could, for instance, encourage fishermen to turn to use of illegal gear and harvest of immature fish. Nile Perch is a major national/regional export and a decline in annual revenue may limit private/State initiatives and investment in the fishing industry.

5.1.1.7. Threats and trends

In case of persistence of pollution and overexploitation (legal and illegal) of fish and their habitat, the following threats and trends are envisioned:

i) Further decline and commercial extinction of endangered species such as *Haplochromines*
ii) Further loss of natural spawning grounds;
iii) Further loss of genetic diversity of commercial fish populations caused by:
    a) Reduction of natural spawning
    b) Adverse impact of stock enhancement (restocking) and
    c) Introduction of exotic species and hybrids due to the development of aquaculture.

iv) Further loss of biodiversity caused by adverse ecological impacts such as targeting and over fishing certain key species (e.g. population and ecosystem imbalance);
v) Continued reduction of economic income for coastal communities and States; and
vi) Lower government and private investments in fisheries research, rehabilitation, and management.

5.1.2 .Threats to biodiversity: Strongly transboundary

5.1.2.2. Statement of the Problem

Concern over loss of biodiversity in Lake Victoria (at species, genetic, and habitat levels) is widespread internationally and regionally. Species biodiversity of Lake Victoria is *high/low* compared to other lakes across nearly all phyla. The clear threats to some of the economically important fish species (including Haplochromines)) heighten concern over general loss of biodiversity. Two major flagship species in Lake Victoria, the Haplochromines and Cichlids (*labeo, Synodonties* etc) are officially classified as threatened. The high rate of species endemism in Lake Victoria would suggest that biodiversity may be particularly sensitive to threats from industrial pollution, over fishing, invasion of exotic species, and other human activities.

5.1.2.2. Supporting data

The supporting data for biodiversity threats is outlined in section 3. The major factors threatening decreased biodiversity of Lake Victoria are

i) Interference of inflowing rivers –water destruction
ii) Illegal fishing and over-fishing
iii) Water level changes
iv) Pollution
v) Invasive and Introduced species
vi) Climate change

a) River regulation

Regulation of rivers that flow into Lake Victoria could be one of the most significant anthropogenic impacts on the biodiversity of the lake. From the period of the 1970s to the 2000, dozens of reservoirs (Panpaper, Mumias, Muhoroni, Chemilil) were built on Lake Victoria rivers for the purposes of agriculture and hydroelectric power. Regulation of river flow has both chronic and acute impacts. Changes in the hydrological regimes, reducing spring run-off, can lead to increased shoaling of river delta and reduction in the area of delta vegetation (reeds, cat-tail, and bushes). This loss of vegetation can result in a loss of aquatic fauna and many migratory and semi-migratory species are deprived of their natural spawning grounds. As spring flows are reduced, fish migration upriver for spawning is impeded and essential nursery areas are limited.

b) Over-fishing and illegal fishing

Over-fishing has contributed to the complete loss of some species of fish. In the 1920-40s typical commercial species were Haplochromines, Tilapiines, Dagaa etc. Besides Nile perch, all these species are now of little commercial value except Tilapia and Dagaa.

c) Lake Victoria water level change

Lake Victoria water level change is one of the most important natural phenomena that may affect the biodiversity of this huge water body. Historical natural water level fluctuations, due to changes of climate and river discharge into Lake Victoria, may have a short and long-term impact. Short-term impacts include seasonal or wind-induced changes of water level. Seasonal changes of water level of the lake can reach almost *0.5* m, whereas under the influence of surges, it can rise *1.5-2* m. In the west of the Eastern side of Lake Victoria, surges (El Nino) cause inundation of the coastline up to 50m onshore, while retreats cause exposure of *20*m of the lakebed. From late 2000 to 2005, the level of Lake Victoria decreased by almost *5* m. Such a significant change could have a negative impact on its flora and fauna. Most parts of the lake shoreline and wetlands are bound to suffer most. Shallow bays such as Kusa, Kendu etc has dried and the river deltas of Nyando Awach etc reduced significantly. Changes in the level of Lake Victoria caused by human activity can have an indirect impact on biodiversity. Dredging/sand harvesting is an example. Construction of a dam at the head of the Sondu Miriu river serves as another example.

d) Pollution

Pollution is an often-quoted threat to the biodiversity of Lake Victoria. The sources of pollution are industry, agriculture, accidental discharges, and sewage. The main flow of pollution comes from the agricultural farms, urban sewages but the levels of contaminants organic, inorganic and faecal detected in the lake waters; fish and sediments indicate a relatively clean lake. Of more concern are the pollution hot spots of Kisat river, Homa Bay, and river mouths of Nzoia, Yala, and Nyando.

e) Climate change impact

The impact of climate changes on the biological diversity of Lake Victoria may not be well studied. A majority of the scientists believe that the impact of climate changes on the biodiversity of the Lake Victoria is indirect, through climate impact on the lake level, which could significantly alter its biodiversity. However, the impact of climate change on biodiversity may be weak compared to other causes.

5.1.3. Degradation of landscape and damage to catchment habitat

5.1.3.1. Statement of the problem

The lake basin has lost a large portion of its vegetative cover and soils. This has caused damage to the catchment habitat and degradation of landscape. The main reasons are deforestation, overstocking livestock and soil erosion.

5.1.3.2. Supporting data

There has been serious reduction in most forests in the Lake Victoria basin. For example; 7,084 Ha of Mau Forest lost in 2000-2003, clearing of about 35% of indigenous forests within Narok area and a loss of 1,029 Ha in Mt Elgon (See Section 3).

5.1.3.3. Causal chain analysis

The immediate causes are deforestation, soils erosion, poor farming practices and overstocking livestock. Inadequate compliance with and enforcement of legal regulations, weak economic situations, absent or inadequate national and regional EIA processes, population growth and inadequate public awareness are the underlying causes.

5.1.3.4. Sectors and stakeholders

Municipal and regional governments; Ministries in charge of environment, energy, agriculture, livestock and fisheries; Relevant industries etc.

5.1.3.5. Environmental impacts

Degradation of land scape and damage to catchment adversely affect the lake basin ecosystem .Both land based and water based organisms are adversely affected, destruction of vegetation, migration of animals, birds, alteration of species composition, density and distribution.

5.1.3.6. Future threats and trends

The combined socio-economic pressures and accompanying stressors will result in increased land encroachment and possibly more contamination and in turn degradtion of landscapes and habitats.

5.1.4. Overall Declines in Environmental Quality: Strongly Transboundary

5.1.4.1. Statement of the problem

Decline in environmental quality includes the decline in air, water and sediment quality, damage to ecosystems due to human activities, loss of aesthetic appeal, and related issues.

5.1.4.2. Supporting data

The supporting data for decline in environmental quality is outlined section 3.

5.1.4.3. Causal chain analysis:

Causal chain analyses (Figure 5.2) have identified some of the root causes of the overall environmental decline, including socio-economic conditions (transition economies), inadequate enforcement, and lack of effective NGO. Lack of market forces, government will and resources to combat the problem, non-functional urban sewage systems, non-compliance to environmental laws and regulations, weak enforcement of the laws, lack awareness among key stakeholders etc.

5.1.4.4. Sectors and stakeholders

Public healthcare providers, multinational corporations, regional and municipal governments and fishermen are the key sectors and stakeholders. The major governmental players include Agriculture and Fisheries Ministries, municipal and regional governments, Environment ministries, and State industries. Affected stakeholders include lakeshore residents, NGOs, public health care providers, Agricultural and Fisheries Ministries, and multinational corporations. Environment

ministries are also affected stakeholders, though not to the extent of the stakeholders above.

5.1.4.5. Environmental impacts

Environmental impacts are varied. Biodiversity may be threatened. Fish, and other organisms may accumulate high levels of some contaminants (particularly organochlorines), which affect their life history; Habitats could be altered and perhaps lost, though the extent of this effect is still inadequately documented. Human health effects may result (again, documentation is poor).

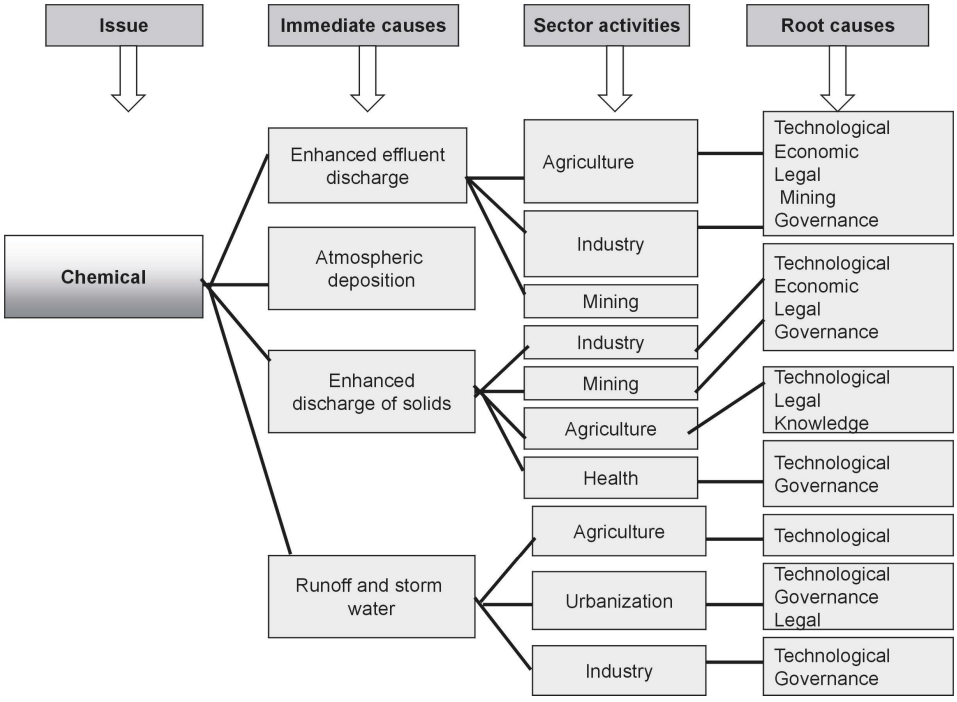


Figure 5.2 Causal chain analysis for chemical pollutants

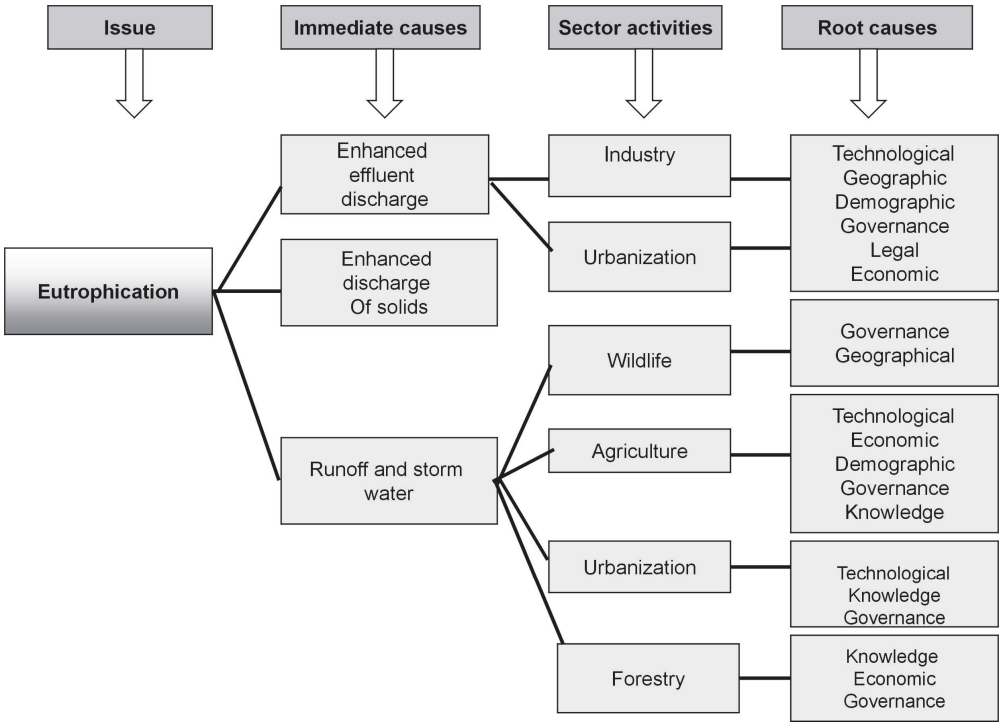


Figure 5.3 Causal chain analysis for Eutrophication

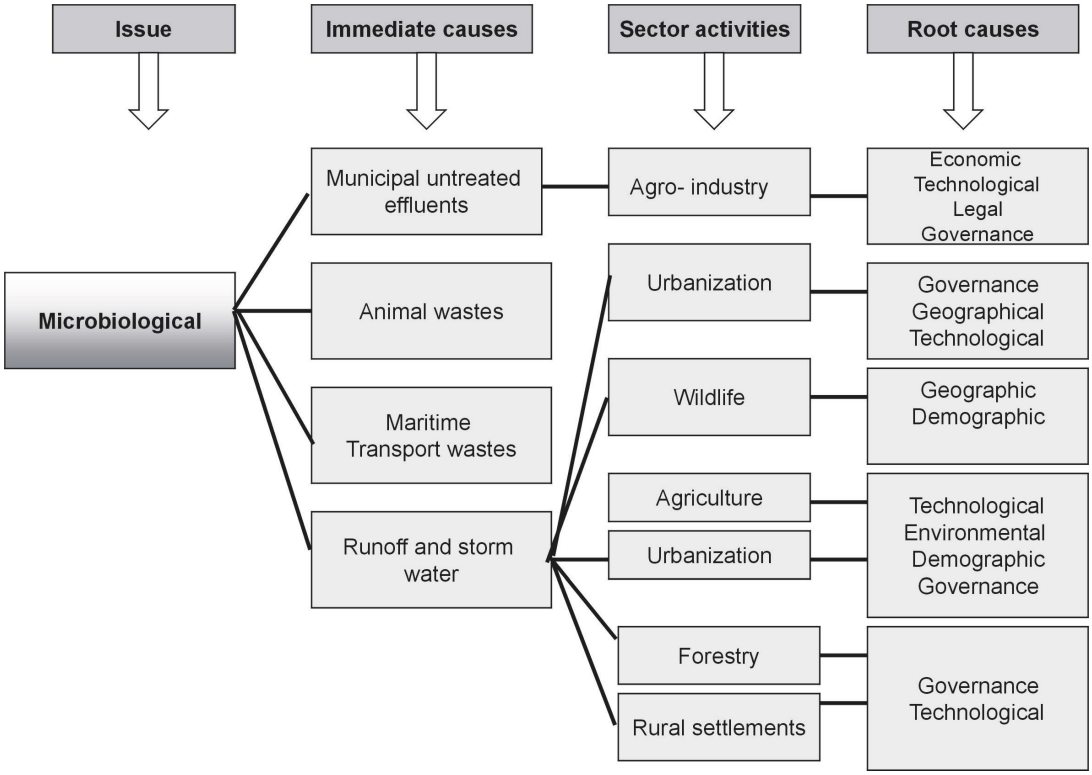


Figure 5.4 Causal chain analysis for microbiological pollutants

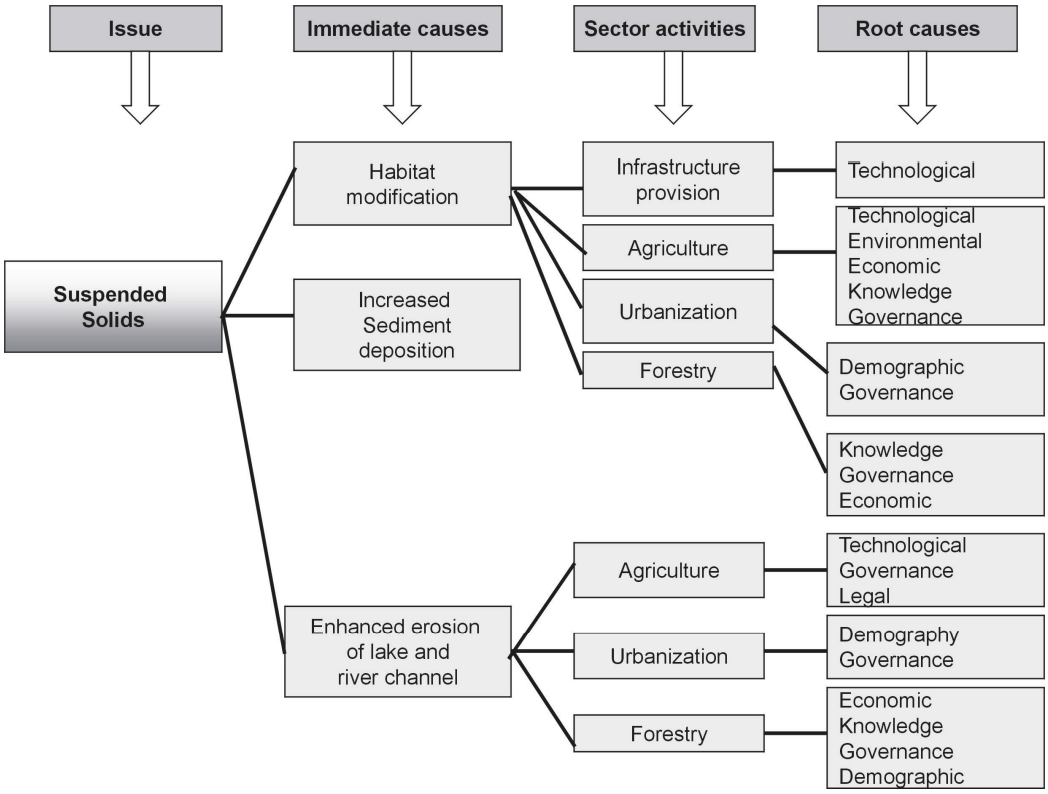


Figure 5.5 Causal chain analysis for total suspended solids

5.1.4.6. Socio-economic impacts:

Human health may be affected by industrial pollution, both through direct contact with the waters (for instance, microbiological contamination in swimming/bathing/ fishing waters), as well as contact through eating fish and drinking water. Air quality may also affect human health. Fish export bans by importing countries (EU)

5.1.4.7. Future trends

The future is difficult to predict, but there are several aspects worth considering that threaten the Lake Victoria basin. Therefore, national, regional and international standards and technology must be combined with emergency planning and preparedness, on a regional basis.

5.1.5. Invasive and introduced species: Strongly transboundary

5.1.5.1. Water hyacinth re-infestation

5.1.5.2. Statement of the problem

In the recent past the Lake Victoria basin witnessed increased infestation with with introduced/invasive fish and weeds

5.1.5.3. Supporting data

Information on the invasive weeds is contained in section 3.

5.1.5.4. Causal chain analysis

Root causes identified include the lack of regional agreements on review and approval of introductions of exotic species within the Lake Victoria basin, inadequate regulations governing the plant trade, inadequate customs procedures, and lack of public awareness. High levels nutrients in the lake arising from the catchments farms and industries.

5.1.5.5. Sectors and stakeholders

No stakeholder groups ranked invasive species and introduced as a high priority issue/problem. Fishermen, public healthcare providers, and multinational corporations expressed the greatest concern. The primary interested government parties include fisheries and environment ministries. Contributing stakeholders include transport companies and some multinational companies/corporations. Affected Stakeholders include fishermen, agriculture/fisheries ministries, scientific community, lakeside communities, and NGOs.

5.1.5.6. Environmental impacts

Invasive and Introduced species may take over an ecological niche unfilled by existing organisms, or they may out-compete local organisms. Local organisms may disappear and perhaps become extinct, decreasing biodiversity. Competition for food resources may disrupt the food chain. Habitats may be disrupted and destroyed. Fisheries may collapse if recruitment processes are affected.

5.1.5.7. Socio-economic impacts

A variety of socio-economic impacts may occur, including loss of livelihood, resulting in poverty and/or increased pressure for poaching; decline in commercial activity, in for instance, the fisheries sector; and destruction of aesthetic quality (eutrophication, for instance, leading to decreased air quality or visual corridors).

5.1.5.8. Future threats

Work performed to date on the spread of water hyacinth shows this species to be re-emerging at scattered sports especially sheltered bays .The introduced weevils tend to die off there is therefore need for monitoring and re-introduction of the weevils.

5.1.6. Decline in human health

5.1.6.1. Statement of the Problem

The general standards of health in the Lake Victoria region are low. A health and demographic surveillance set up within the Lake Victoria basin shows that life expectancy at birth within the surveillance site is 38 years, infant mortality rate 125 per 1000 live births, and under-five mortality rate stood at 227 per 1000 live births (Adazu *et al.* 2005). Predominant health issues in the region are linked to vector-borne diseases, unsafe water contaminated by microbial and chemical

pollutants and poor disposal of human waste, and food insecurity leading to malnutrition. Emerging and other infectious diseases such as HIV/Aids and related illnesses, T.B, Upper Respiratory Diseases and Accidents (Table 3.41) also heavily burden the region.

5.1.6.2. Supporting data

Data on decline in human health is given section 3 of this report.

5.1.6.3. Causal chain analysis

The major causes of decline in human health arise from poor quality drinking water, poor sanitation, environmental factors etc.

5.1.6.4. Sectors and stakeholders

Stakeholders include public healthcare providers (MoH), multinational corporations, and industry. Also Municipal councils Ministries in charge of environment, agriculture, livestock, fisheries, health, and to a lesser extent, energy; The major stakeholder in air pollution are industries such molasses, PanPaper, Agrochemical etc.

5.1.6.5. Environmental impacts

Because the actual causes of human health decline are often unclear and inclusive, proxy measures for environmental stressors are used. These include:

a) Increase in infant mortality, increase in infants with low birthrate, increase in under five mortality rate, increase in undernourished people, and decrease in life expectancy in the basin.
b) Access to portable water
c) Infectious diseases rates increase
d) Increase in pollution related disease rates and birth defects
e) Increase in water borne illnesses
f) Decline in cloric value

5.1.6.6. Socio-economic impacts

Increased loss of life, increased level of illness and disease with increased social costs for health, loss of economic labour base, and loss of productivity by lake basin residents.

5.1.6.7. Future threats

Municipal wastes remain largely untreated with an increase in water-borne illnesses, especially if droughts prevail. Water level significantly affects the disposal of municipal wastes.
Cost sharing may affect the very poor in accessing medical treatment.

5.1.7. Damage to catchment infrastructure and amenities

5.1.7.1. Statement of the problem

The water level fluctuations of Lake Victoria negatively affect lakeshore infrastructure and related amenities. As the water level drops, water-related structures (piers, jetties etc) may no longer be useable and the water level rises, previously dry areas will be inundated, causing damage to infrastructure.In

addition to long term water level fluctuations, wind-induced or storm-induced surges can cause considerable flooding of exposed lake shore areas. Lack of planning at all levels has led to development that ignores water level fluctuations.

5.1.7.2. Supporting data

The water level for Lake Victoria has declined by about 1.5m.

5.1.7.3. Causal chain analysis

Many causes are natural. The causal chain focuses on human response to the forces causing water level change. The primary root causes include inadequate knowledge of long-term trends of changes in water levels, unplanned regional developments e.g. Hydro-power station at Jinja.

5.1.7.4. Sectors and stakeholders

Multinational companieslake shore residents, fishers, marine transporters.

5.1.7.5. Environmental impacts

Change of ground water table responding to fluctuations in surface water, loss of lake habitats as infrastrure needs compete with lake habitats that normally migrate with fluctuating water level.

5.1.7.6. Socio-economic impacts

The socio-economic impacts include costs of livelihood, infrastructure repair at the expense of other social programs, loss of jobs and displacement of lake residents. National budgets may be diverted towards commercial interests (e.g. shipping ports, flood protection).

5.1.7.7. Future threats

Uncertain water level fluctuations due to unpredictable weather patterns

5.1.8. Conflicts in resource use

5.1.8.1. Statement of the problem

In the recent past, the Lake has witnessed conflicts in resource use, including; cattle rustling, access rights, cross-border fishing, water use, wetlands degradation, forest destruction, wildlife migration and increased incidences of bush fires.

5.1.8.2. Supporting data

There is little data available on resource conflicts in most sectors. However, there is some information in Section 3.17 of this report.

5.1.8.3. Causal chain analysis

The main causes of resource conflicts include;

i) Piracy and robbery

ii) Weak and non-transparent enforcement of law and regulations
iii) Smuggling of goods across borders
iv) Lack of protection of property rights
v) Uneven development across regions
vi) Over-capacity of fish processing plants
vii) The Nile Treaty
viii) Clearance of forests for timber, firewood and settlements
ix) Use of wetlands especially for agricultural purposes
x) Cultural practices
xi) Unmarked boundary
xii) Declining fish stocks
xiii) Diversion of river course
xiv) Slash and burn cultivation
xv) Forest cultivation
xvi) Lack of water/pasture
xvii) Water decline
xviii) Cattle rustling
xix) Wetlands degradation
xx) Forest destruction
xxi) Cross-border fishing

5.1.8.4. Sectors and stakeholders

The main sectors are fisheries, forestry, water, wetlands, agriculture

5.1.8.5. Environmental and social impacts

The environmental and social impacts include;

a) Loss of biodiversity
b) Loss of resources
c) Loss of life
d) Economic loss
e) Increase soil erosion and hence siltation of river beds
f) Sedimentation/siltation
g) Air pollution
h) soil erosion
i) Human/animal conflicts

5.1.8.7. Future threats

Conflicts are bound to recur unless mitigations and conflict resolution mechanisms are put in place to address problems as they occur.

5.1.9. Flooding

5.1.9.1. Statement of the Problem

Floods are a persistent problem in the flood plains of Lake Victoria. In particular Kano Plains, Budalangi and Aneko are usually flooded annually during long rains, and sometimes also during short rains. The major rivers flowing into Lake Victoria that are prone to flooding are rivers Nyando, Yala, Nzoia and Migori-Kuja.

5.1.9.2. Supporting data

There is scanty data on floods.

5.1.9.3. Causal chain analysis

The causes of the floods are lack of dams along the rivers, inadequate control measures, lack of fore planning and inadequate forecasting as well as environmental factors.

5.1.9.4. Sectors and stakeholders

Communities along the rivers, Ministries of public works, health, environment, Meteorological department

5.1.9.5. Environmental impacts

Destruction of dykes, roads; increase in water-borne diseases; Erosion; Destruction of landscape.

5.1.9.6. Socio-economic impacts

Loss of human lives, property; destruction of infrastructure; disruption of livelihoods; decline in agricultural and economic activities.

Floods will continue to cause problems in the lake basin unless remedial measures are put in place, including; Flood control measures e.g. dam construction, Forest management and Good agricultural practices

SECTION 6. STAKEHOLDER ANALYSIS

This section discusses the stakeholder analysis for the Lake Victoria basin in relation to the major perceived problems and issues. In addition it includes a comprehensive analysis of transboundary issues from the National perspective and proposes methods of addressing the problems to ensure maintaince of ecosystem health and management of pollution.

6.1. Stakeholder analysis

The Global Environmental Facility TDA Guidelines Document recommend a stakeholder analysis should be performed in support of any TDA, including 'a description of all the stakeholders, including institutions, organisations, ministries, and industry related to the perceived problems and issues. The information pertaining to this list includes the effect of the stakeholders, the nature and effectiveness of the interactions between the stakeholders as well as their strengths and weaknesses in view of their actual and /or potential role in managing water and water dependent resources.

A stakeholder may be defined as an agency, organization, group or individual who has a direct or indirect interest in a project/ programme, or who affects or is affected by the implementation and outcome of it. Stakeholders are characterized by having; wide and varied views, values, ideals, cultural outlook, interests, power and conflicts. stakeholders may be classified as:

i) Primary/ principal stakeholders or beneficiaries
ii) Secondary stakeholders (e.g. NGOs, research institutes, Government institutes, etc.
iii) External stakeholders
iv) Target groups (usually the same as the beneficiaries)
v) Implementation partners.

Stakeholder analysis is an approach for understanding a system by identifying the key actors – or stakeholders in the system and assessing their respective interest (and involvement) in that system. It also refers to a range of tools for the identification and description of stakeholders on the basis of their attributes, interrelationships and interests related to a given initiative or resource.

The importance of stakeholder analysis is;

i) To identify all those people, groups or institution who might be affected by an intervention or can affect its outcome,
ii) To identify local institutions and processes upon which to build,
iii) To empirically discover existing patterns of interactions,
iv) To make a start with understanding needs and interests of the key stakeholders,
v) To provide a foundation and strategy for participation: Mobilization of key stakeholders, building up common awareness, creating ownership,
vi) To better target interventions and approaches,
vii) As management tool in policy making and
viii) As a tool to predict and/or manage conflicts.

The important stages in stakeholder analysis are:

a) Before the situation analysis starts i.e When defining the scope of the policy/ project
b) During the problem identification and analysis –i.e to mobilize stakeholders and to analyze the stakeholders' needs and interest, objectives linkages and interactions, etc,and
c) While designing the project strategy or policy i.e to balance conflicting interests and to assure commitment or participation in implementation.

During stakeholder analysis a number of key questions are considered. They include;

a) Who are the stakeholders in a system, with regard to a certain project/ programme?
b) What are their interests, views, and objectives?
c) How important are they?
d) How are they affected?
e) How can they affect/ influence the project or programme outcomes?
f) What kind of relations do thay have with the project or program.?
g) How should stakeholders participate or contribute?
h) Which problems, affecting which stakeholders, does the project seek to address or alleviate?
i) For which stakeholders does the project place a priority on meeting their needs, interests and expectations?
j) Which stakeholder interests converge most closely with policy and project objectives?

The stakeholder analysis, therefore, involves a situational analysis of the following;

1. Stakeholders: Who are they are, their resources, interactions, power relations and their interest?
2. Issues, problems: (What the focus is and the stakeholder perspectives)
3. Biographical setting: (The main geographical characteristics climatic conditions that determine the forms of land use and environmental problems or risks)
4. Infrastructure: (Key infrastructure issues).
5. Institutions: The following institutional aspects are considered;
    a) Organisations: (Important government, business and NGO organizations performance? Linkage (power relations, communications, joint work, competitors).
    b) Legal policy & political: (Significant legal factors; Significant government policies and programmes; Main government and policies political structures and processes;)
    c) Economic, Market: (Economic situation; Main forms of economic livelihood; Key characteristics of the local economy; Market opportunities and constraints)
    d) Socio – Cultural: (The main social and cultural conditions relevant to the project should be identified)

Different stakeholders have different influence and importance, therefore in analysing them the steps followed are:

i) Identification of stakeholders,
ii) Their interests in relation to problem addressed,
iii) Assessment of the influence or power of the stakeholder,
iv) Combining their influence and importance in matrix diagram,
v) Identifying risks and assumptions for stakeholder cooperation,
vi) Determining how and which stakeholders should participate in the project cycle activities.

Influence is basically defined as the power which stakeholders have over a project to control what decisions are made, facilitate its implementation, or exert influence, which affects the project negatively.or the extent to which the stakeholder is able to persuade or coerce others into making decisions and following certain course of action. Importance is basically the priority given to satisfying stakeholders' needs and interests through the project. It is likely to be most obvious when stakeholders interests in the project converge closely with the project objectives.

The variables affecting stakeholders in relation to power and influence include:

i) Within and between formal organization:
   a) Legal hierarchy i.e command and control, budget holders,
   b) Authority of leadership (formal, informal, charisma, political or cadre connections,
   c) Possession of specialist knowledge and skills and
   d) Negotiating position i.e. strength in relation to other stakeholders.

ii) For informal interest groups and primary stakeholders:
   a) Social, economical and political status,
   b) Degree of organization consensus and leadership in the group,
   c) Degree of control of strategic resources significant for the project,
   d) Informal influence through links with other stakeholders,and
   e) Degree of dependence on other stakeholders

Table 6.1, 6.2 and 6.3 shows stakeholders group prioritization of Major Perceived Problems and Issues for causes, effects and solutions ,respectively.

Table 6.1: Stakeholder Group Prioritization of MPPI -Causes (H =High priority; M=Medium Priority; L=Low Priority)

Stakeholder	Decline in endemic and commercial fish sp.	Threats to biodiversity	Degradation of landscape and damage to catchment habitat	Overal decline to environmental quality)	Invasive and introduced sp.	Decline in human health	Damage to catchment infrastructure and amenities	Conflicts in Resource use	Decline water level	Flooding	Disaster manage ment
MENR	M	H	H	H	H	H	M	M	M	H	H
MW&I	L	M	M	H	H	L	L	M	H	H	H
ML&FD-FD	H	H	H	M	H	M	M	M	H	L	L
ML&FD-KMFRI	H	H	M	H	H	M	L	L	L	L	L
MA-KARI	M	H	M	M	H	M	H	M	M	L	L
NGOs	M	M	M	M	M	M	M	M	M	L	L
Fishermen	H	H	M	L	H	L	H	M	M	M	M
Farmers	L	M	H	H	M	H	H	H	M	M	M
Livestock keepers	L	H	H	H	L	H	M	H	L	M	M
Artisanal miners	L	L	H	H	L	H	H	H	L	M	H
Wetland users	H	H	H	H	H	H	H	H	H	H	H
Forest inhabitants	L	H	H	H	H	H	H	H	L	L	H
Industries	M	M	H	H	H	H	H	H	H	L	H
MOH	L	L	L	M	L	H	L	L	L	L	L
KWS	H	H	M	L	H	L	L	H	M	L	L
Universities	M	M	L	L	L	L	L	M	L	L	L
Dominion Farms	M	M	M	H	H	H	H	H	H	H	L
KEFRI	L	M	H	M	H	L	H	M	M	L	L

Table 6.2: Stakeholder Group Prioritization of MPPI. -Effects (H =High priority; M=Medium Priority; L=Low Priority)

Stakeholder	Decline in endemic and commercial fish sp.	Threats to biodiversity	Degradation of landscape and damage to catchment habitat	Overal decline to environmental quality)	Invasive and introduced sp.	Decline in human health	Damage to catchment infrastructure and amenities	Conflicts in Resource use	Decline water level	Flooding	Disaster management
MENR	M	H	H	H	H	M	H	H	H	H	L
MW&I	L	M	H	H	H	M	L	H	H	H	H
ML&FD-FD	H	H	H	H	H	M	M	H	M	H	M
ML&FD-KMFRI	H	H	H	H	H	M	L	H	H	H	M
MA-KARI	M	H	H	M	H	M	L	H	H	H	M
NGOs	L	M	M	M	M	M	M	M	M	H	H
Fishermen	H	H	M	M	H	H	M	H	H	H	H
Farmers	L	M	H	H	M	H	H	H	M	M	M
Livestock keepers	L	H	H	H	L	H	M	H	L	M	M
Artisanal miners	L	L	H	H	L	H	H	H	L	M	H
Wetland users	H	H	H	H	H	H	H	H	H	H	H
Forest inhabitants	L	H	H	H	H	H	H	H	L	L	H
Industries	M	M	H	H	H	H	H	H	H	L	H
Industries	H	M	L	M	L	H	L	M	H	L	M
MOH	L	M	L	M	L	H	L	L	L	L	L
KWS	H	H	H	M	H	L	M	H	H	M	M
Universities	L	H	M	H	L	M	L	L	L	L	L
Dominion Farms	L	L	L	L	L	L	L	H	H	H	L
KEFRI	L	H	H	M	H	L	H	H	H	L	L

Table 6.3: Stakeholder Group Prioritization of MPPI. –Solutions (H =High priority; M=Medium Priority; L=Low Priority)

Stakeholder	Decline in endemic and commercial fish sp.	Threats to biodiversity	Degradation of landscape and damage to catchment habitat	Overal decline to environmental quality)	Invasive and introduced sp.	Decline in human health	Damage to catchment infrastructure and amenities	Conflicts in Resource use	Decline water level	Flooding	Disaster management
MENR	H	H	H	H	H	L	H	H	H	H	L
MW&I	M	H	H	H	H	L	L	H	H	H	H
ML&FD-FD	H	H	H	H	H	L	L	H	M	M	M
ML&FD-KMFRI	H	H	H	H	H	L	L	H	M	M	L
MA-KARI	M	H	H	M	H	M	H	H	M	M	L
NGOs	L	M	M	M	M	M	M	M	M	H	H
Fishermen	H	H	L	L	H	L	L	H	M	L	H
Farmers	L	M	H	H	M	H	H	H	M	M	M
Livestock keepers	L	H	H	H	L	H	M	H	L	M	M
Artisanal miners	L	L	H	H	L	H	H	H	L	M	H
Wetland users	H	H	H	H	H	H	H	H	H	H	H
Forest inhabitants	L	H	H	H	H	H	H	H	L	L	H
Industries	M	M	H	H	H	H	H	H	H	L	H
Industries	L	M	M	H	L	H	L	M	M	L	H
MOH	L	L	L	M	L	H	M	L	L	L	H
KWS	H	H	H	M	H	L	M	M	M	M	M
Universities	H	H	H	H	H	H	L	L	M	H	M
Dominion Farms	M	H	H	M	L	L	H	H	H	H	L
KEFRI	L	H	H	M	M	L	H	H	H	H	L

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Table 6.4 List of stakeholders by sector

Sectoral transboundary issues	Stakeholders
Land • Agriculture • Settlements • Urban development • Hydroelectric power • Brick making/pottery • Infrastructure ▪ Roads ▪ Passages ▪ Canals ▪ Sewerage ▪ Power transmission	**Users** • Farmers (Crops and livestock) **Research and extension** • KARI • Universities (Moi, Kenyatta, Nairobi and Egerton and WUCST, etc.) • Ministry of Agriculture • NIB • KWS • LBDA • NEMA • Local authorities • NGOs (Care Kenya, OSIENALA, Action Aid, Kenya) • Ministry of Roads • Ministry of Environment and Natural Resources • Ministry of Energy **Private investors** • Dominion Group • Sugar Industry (Muhoroni, Mumias, Chemelil, Sony, West Kenya, Kabras, and Jaggeries) • Tea Industry (Unilever, James Finlay etc) • Dairy Industry
Water (Lakes, rivers, Satellite lakes, dams, boreholes) ○ Irrigation ○ Domestic use ○ Animals ○ Transport ○ Industrial use ○ Waste discharge ○ Hydroelectric power ○ Boreholes ○ Pollution ▪ Eutrophication ○ Declining in water levels in lakes and rivers ○ Invasive plants (Water hyacinth- *Eichhornia crassipes*)	**Users** • Fishers • Farmers • Transporters (Kenya Railways, Private transporters) **Research and extension** • KARI • Universities (Moi, Kenyatta, Nairobi and Egerton and WUCST etc) • Ministry of Agriculture • NIB • KWS • NEMA • LBDA • KMFRI • Ministry of Fisheries and Livestock (Fisheries Department) • Ministry of Water and Irrigation • Local authorities • NGOs (Care Kenya, OSIENALA, Action Aid, Kenya) • Ministry of Environment and Natural Resources • Ministry of Transport and Communications • Ministry of Energy • FAO • Nile Basin Initiative • LVFO • Lake Victoria Basin Commission **Private investors** • Dominion Group • Sugar Industry (Muhoroni, Mumias, Chemelil, Sony, West Kenya, Kabras, and Jaggeries) • Tea Industry (Unilever, James Finlay etc) • Dairy Industry • Water boards (KIWASCO, Kisumu,)
Wetlands ○ Drainage ▪ Agriculture ○ Biomass harvesting ○ Sand harvesting	**Users** • Fishers • Farmers • Biomass harvesters **Research and extension**

Sectoral transboundary issues	Stakeholders
○ Brick making and pottery ○ Fire threats ○ Ecotourism ○ Traditional salt harvesting ○ Agrotourism ○ Medicinal ○ Pasture ○ Fishing ▪ Biodiversity conservation	• KARI • East African Wildlife Society • Universities (Moi, Kenyatta, Nairobi and Egerton and WUCST etc) • Ministry of Agriculture • NIB • KWS • LBDA • KMFRI • IUCN • NEMA • Ministry of Fisheries and Livestock (Fisheries Department) • Ministry of Environment and Natural Resources • Ministry of Water and Irrigation • Local authorities • NGOs (Care Kenya, OSIENALA, Action Aid, Kenya) • Ministry of Roads • Ministry of Energy • KIPPRA • NEMA **Private investors** • Dominion Group • Sugar Industry (Muhoroni, Mumias, Chemelil, Sony, West Kenya, Kabras, and Jaggeries) • Tea Industry (Unilever, James Finlay etc) • Dairy Industry • Water boards (KIWASCO,)
Forestry ○ Fuelwood extraction ○ Timber ○ Wildlife ○ Settlement ○ Agriculture (Nyayo tea zones) ○ Cultural values ○ Pasture ○ Medicinal	**Users** • Wood fuel harvesters • Timber harvesters **Research and extension** • KEFRI • Universities (Moi, Kenyatta, Nairobi and Egerton and WUCST etc) • Ministry of Agriculture • KWS • NEMA • LBDA • Kenya Railways • Ministry of Environment and Natural Resources • Local authorities • NGOs (Care Kenya, OSIENALA, Action Aid, Kenya) • Ministry of Energy • KIPPRA **Private investors** • Dominion Group • Sawmillers • Sugar Industry (Muhoroni, Mumias, Chemelil, Sony, West Kenya, Kabras, and Jaggeries) • Tea Industry (Unilever, James Finlay etc)
Pasture ○ Overstocking ○ Agriculture ○ Settlements ○ Climate	**Users** • Pastoralists • Farmers • Squatters and landless **Research and extension** • KARI • Universities (Moi, Kenyatta, Nairobi and Egerton and WUCSTetc) • KWS • LBDA • Ministry of Environment and Natural Resources • Local authorities • NGOs (Care Kenya, OSIENALA, Action Aid, Kenya) **Private investors**

Sectoral transboundary issues	Stakeholders
	• Dairy industry • Private butcheries
Minerals • Soapstone harvesting • Construction stones • Cattle lick • Gold prospecting • Mercury use in gold prospecting • Lime extraction	**Users** • Mineral prospectors • Gemstone and Jewelry dealers **Research and extension** • Universities (Moi, Kenyatta, Nairobi and Egerton and WUCST, etc.) • Ministry of Environment and Natural Resources (Geology and Mines Department) • Local authorities **Private investors** • Cosmetic industry • Tourism
Fisheries ○ Cross border fishing ○ Cross border trade ○ Industrial capacity ○ Fishing gear ○ Over fishing	**Users** • Fishers • Fish traders • Beach Management Units • Fisheries Cooperatives **Research and extension** • KMFRI • Universities (Moi, Kenyatta, Nairobi and Egerton and WUCST, etc.) • Ministry of Livestock and Fisheries (Fisheries Department) • LBDA • Ministry of Environment and Natural Resources • Local authorities • FAO • LVFO • EU **Private investors** • Fish processors
Wildlife • Agriculture • Settlements • Forests • Wetlands • Water • Game hunting and poaching • Ranching • Tourism	**Users** • Tourists • Local authorities **Research and extension** • KWS • Universities (Moi, Kenyatta, Nairobi and Egerton and WUCST, etc.) • National Museums of Kenya • Ministry of Environment and Natural Resources **Private investors** • Game ranchers
Cultural sites- religion • Conservation e.g.Ramogi Hills	• Users • Local Authorities • Alternative medical practitioners • Churches **Research and Extension** • Ministry of Environment and Natural Resources • NEMA • Universities (Moi, Kenyatta, Nairobi and Egerton and WUCST, etc.) • National Museums of Kenya
Energy • Destruction of forests • Hydroelectric power generation	Users • Industries • Households **Research and extension** • Universities (Moi, Kenyatta, Nairobi and Egerton and WUCST, etc.) Ministry of Environment and Natural Resources **Private Institutions** • Private power producers (Westmont, Mumias, Iberia)

6.2. TDA Priority Interventions

A comprehensive analysis of transboundary issues from a national perspective and the proposed methods of addressing the problems to ensure maintance of ecosystem health and management of pollution are shown in table 6.4 below.

Table 6.5 Issues and interventions

Issue	Problem	Cause	Impacts	Interventions
Fisheries	-Destruction of the fish breeding areas and threat to several aquatic species -Decline in stocks	-Overpopulation -Open access policy -Lack of alternative source of livelihood	-Increase in fishing effort -Overexploitation	-Population control -Limit access to fishery -Alternative sources of livelihoods- -Fish farming
Water hyacinth infestation	-Transport hinderance -Increase in pests and diseases -Destruction of fishing gear	-Uncoordinated introductions	-Transport blockage -Increase in diseases, pests etc.	-Proper management of the hyacinth weed
Pollution	Discharge of agro-chemicals into rivers/lakes	-Industrial discharge -Municipal discharge	-Eutrophication	-Solid waste management
Persistent Organic Pollutants (POPs) Biological Oxygen Demand (BOD)	-Discharge of agro-chemicals into rivers/lakes	-Improper use of agro-chemicals on farms -Improper runoff and drainage systems	-Chronic/acute toxicity to aquatic life -Ban of fish imports from Lake Victoria	-Good agricultural practices -Effluent treatment
Land use/sedimentation	-Deforestation -Siltation -Reduced availability of water -Soil erosion	Cutting of trees/grass for charcoal burning and logging	-During dry season, dust storms contribute to respiratory problems. -Loss of wine calabash, honey quiver, medicianal plants, lack of fuel wood/building materials. -Reducing of lake /river depths leading to decrease of fish -Food insecurity, Lack of water for livestock, sanitation	-Afforestation -Soil conservation
Water Quality	-High levels of faecal coliforms -Disposal of domestic and industrial wastes	-Discharge of raw/untreated sewage into rivers/lakes	-Diarreahal diseases	-Proper treatment of sewage before discharge
Climate change	Temperature rise (global warming) -Flooding -Changing rainfall pattern -Severe droughts -Increase in severe weather events	-Emission of carbon dioxide -Deforestation -	- Temperature changes affects currents, changing the migration corridors of fish -Fall in agricultural yield, Food shortages -Biodiversity loss due to global warming -Changes in reproductive cycles, growing seasons and frequency of pests and diseases -Affect fish stocks -Prolonged	-Gather reliable data to assess the threat. -Help farmers to identify crops/species of fish and farming practices best suited to the new conditions

			droughts,followed by extremely heavy rainfall over several days.	
Pests and Diseases	-Increase in disease and reduced post-harvest losses	- Environmental factors -Poor agricultural practices -Poor pest and disease management	-Increased mortality	- Preventive and curative measures
Conflicts in resource use	Cattle rustling Cross-border fishing Water use Wetlands degradation Forest destruction Wildlife migration	-Unmarked boundary -Declining fish stocks - Diversion of river course / Planting of Eucalyptus trees on common land boundary	-Drainage of water resource -Increase soil erosion and hence siltation of river beds -During dry season, dust storms contribute to respiratory problems. -Loss of wine calabash, honey quiver, medicinal plants, lack of fuel wood/building materials. -Reducing of lake /river depths leading to decrease of fish -Food insecurity, Lack of water for livestock, sanitation -Deforestation leads to strong winds, which become destructive.	-Improved conflict resolution mechanisms

SECTION 7. EMERGING ISSUES

This Section discusses Emerging Environmental Issues in the Lake Victoria basin. Emerging environmental issues can be defined as issues that are not generally recognized but which may have significant impact on human and/or ecosystem health. Quite often emerging issues are not new issues, however, what is new may be the intensification, wider extension, transformation or changed perception of familiar issues (UNEP 2004).

7.1. Changes in the lake levels

Results of a study conducted for LVEMP-I (Mngodo *et al*. 2005) showe that the Lake Victoria water level has dropped severely by 1.64m between 1998 and 2004. The observed fall in lake level is a result of a combination of two factors; (i) reduced input in terms of rain and inflows into the Lake, and (ii) Increased outflows caused by excess releases at Jinja. On average, inflow consists of 82% rainfall and 18% from basin discharge, while the main outflows are by direct evaporation (76%) and River Nile (24%). Results showed a significant decline in catchment inflows into Lake Victoria of about 14.8% for the 2001-2004 period compared to the long term mean of period 1950-2000. The general absence/ limited rains on the lake in recent years resulted in falling of lake levels with the year 2004 having been severely hit by this shortage of input. On the other hand, the outflow of River Nile increased by 15% in the period 2001-2004 as compared with the long-term average in the period 1950-2000. About 77% of this drop in lake level had occurred in 2003 and 2004.The increased outflow was due to expanded power generation capacity at Jinja. In overall, 45% of the total fall in lake level in the period 2001-2004 could be directly attributed to excess release.

7.2. Avian flu

The Avian flu is caused by the deadly virus of the strain H5N1. It has moved steadily across Asia and into Europe since 2003. It has so far killed over 100 people but remains mostly a virus of birds. In Africa, the confirmed cases have been in Nigeria and Cameroun. The bird flu has the potential to break out in the Lake Victoria basin since the basin lies in the migratory route of the migratory birds. The birds reside in the wetlands such as Yala and Nyando where they feed (refuel) before embarking on the long journal back to the temperate regions in summer. No bird flu cases have been reported so far in the Lake Victoria basin.Bird flu inoculation are in the pipeline and trials have been made by Aventis and Glaxosmithkline on human beings with a view to finding a solution.

7.3. Bioavailability of nutrients

Nutrient loading from the catchment has been the frequently mentioned source of pollution in Lake Victoria pollution especially from the agricultural farms, urban/domestic waste and overstocking of livestock within the catchment. It has been reported that this does not account wholly for the nutrient loads, and suspicion has been raised on the bioavailability of these nutrients from the lake itself. Since this has not been established, there is need to develop research procedures collect relevant data on the subject from Lake Victoria.

7.4. The Nile Treaty

Nile River basin is home to an estimated 160 million people, while almost 300 million live in the ten countries that share the Nile's waters. Within the next 25 years, population within the basin is expected to double, adding to the increased demand for water generated by growth in industry and agriculture. According to the two agreements signed during the colonial era - the 1929 Nile Water Agreement and the 1959 Agreement, Sudan and Egypt were given exclusive rights for the Full Utilization of the Nile waters

In recent years, however, the use of the Nile's waters for development has become a bone of contention among the 10 countries that share its basin - Burundi, Rwanda, the Democratic Republic of Congo (DRC), Tanzania, Kenya, Uganda, Ethiopia, Eritrea, Sudan and Egypt. These countries aver that the colonial era agreements on the use of Nile waters are outdated and need to be revised. They have expressed concern over the long-standing arrangements, arguing the treaties have served to give Egypt unfair control over the use of the river's waters. Thus, there is increasing lobbying to renegotiate the Nile Treaty.

7.5. Highland Malaria

Since 1988 malaria epidemics have occurred in multiple sites in western Kenya highlands. Climatic variability has been associated with some of the recent epidemics. Noboru *et al.* (2002) examined the infuences of climatic factors on the distribution and abundance of three malaria vector species, *Anopheles gambiae, Anopheles arabiensis,* and *Anopheles funestus* in western Kenya and in the Great Rift Valley. Mosquito samples were collected from the lowland and highland areas with various climatic conditions (Table 7.1 and Figure 7.1). The three vector species were abundant in the lower part of western Kenya. *An. arabiensis* was not found in the areas above 1,400melevation in western Kenya. Although *An. Gambiae* and *An. funestus* were found in the sites above 1,700m in western Kenya, their densities were _1 per house. In the Great Rift Valley, *An. gambiae* was not recorded. *An. funestus* was more widely distributed than the other two species. A stepwise multiple regression analysis found that moisture index was the most important variable in shaping species composition of the *An. gambiae* complex. Relative abundance of *An. gambiae* was positively associated with moisture index, suggesting that *An. gambiae* is more adapted to moist climate. Seasonal differences in species composition were significant in western Kenya, and the proportion of *An. funestus* was higher in the dry season than the rainy season. Infuence of temperature on vector density was signiÞcant for all three species. These results imply that climate changes can alter the distribution and abundance of malaria vectors in future and lead to malaria epidemics.

7.6. The Eucalyptus pest (Blue Gum Chalcid) in Kenya

A popular tree, *Eucalyptus,* in Western Kenya used for the supply of fuelwood and timber has recently been infested by the pest -Blue Gum Chalcid *Leptocybe invasa.* The pest was reported in Western Kenya in the year 2003. At the moment the pest has not reached economic threshold. According to the available information from Busia, Bungoma and Vihiga, in the period December 2005, 16% of the trees assessed were lightly attacked, and 4% were severally attacked. A visit to the same locations in March 2006 revealed that the intensity of attack had increased

considerably to 52% but those severely attacked had remained at 4%. The attack seems to be severe in the dry season. Currently, the researchers are running against time to develop integrated pest management strateies for Blue Gum *Eucalyptus* spp. pest *Leptocybe invasa*. The research will target the following areas;

a) Find out which *Ecalyptus* species are tolerant to the pest,and
b) Identify the natural enemies of the pest for an environmentally friendly control of the pest

Table 7.1 Total number *Anopheline* mosquitoes collected in Yala River and Nyando River regions and the Great Rift Valley in Kenya

Season	Areas	*An. gambiae*		*An. arabiensis*		*An. funestus*		Unidentified
		No. (%)	Density[a] (SE)	No. (%)	Density[a] (SE)	No. (%)	Density[a] (SE)	No. (%)
Rainy period	Yala River	609 (73.6)	6.4 (1.4)	126 (15.2)	1.3 (0.5)	90 (10.9)	1.0 (0.3)	3 (0.4)
Dry period	Yala River	133 (51.8)	1.4 (0.3)	17 (6.5)	0.2 (0.1)	104 (40.5)	1.1 (0.3)	3 (1.2)
Rainy period	Nyando River	573 (38.6)	12.7 (2.7)	380 (25.6)	8.5 (1.6)	504 (33.9)	11.2 (4.5)	28 (1.9)
Rainy period	Great Rift Valley	None	None	660 (96.9)	13.2 (3.8)	10 (1.5)	0.2 (0.1)	11 (1.6)

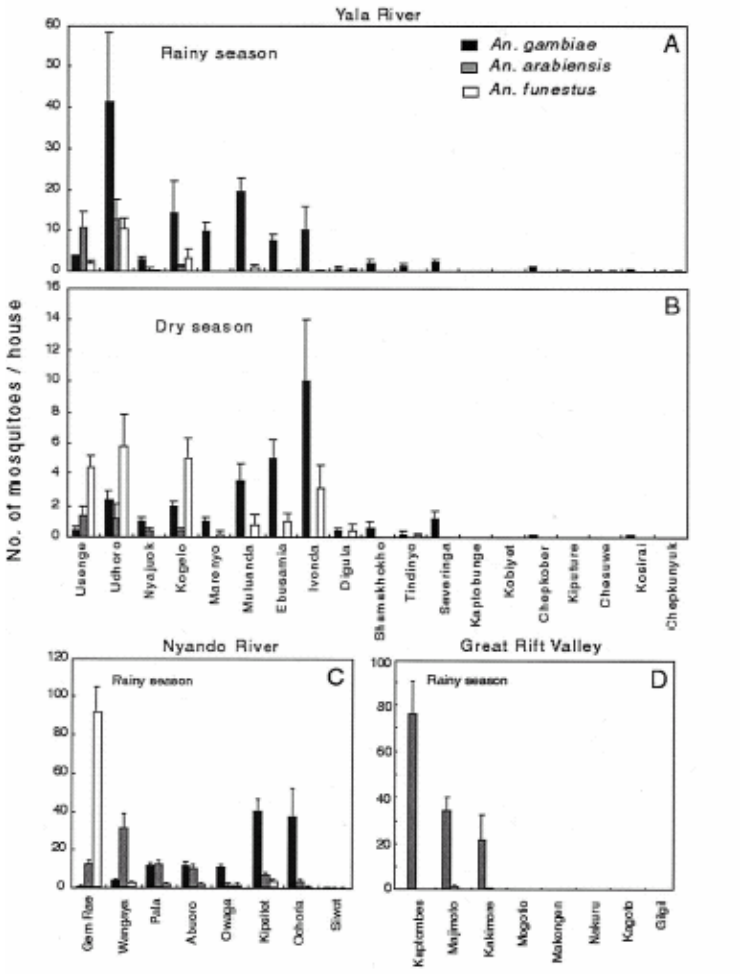

Figure 7.1 Densities of *Anopheles gambiae*, An. arabiensis, and An. funestus in the study sites. **(A)** the Yala River region during the rainy season; **(B)** the Yala River region during the dry season; **(C)** the Nyando River region during the rainy season; and**(D)** the Great Rift Valley during the rainy season. (Adapted from Noboru *et al*. 2001, 2002)

7.7. Recycling of Solid Waste

With increasing release of solid wastes, there is new interest on effective management of waste. Solid waste management has become a critical issue in Kenya with Nairobi alone generating 1500 tonnes of plastic waste daily. One of the emerging issues is management of solid wastes through recycling, particularly of plastic material. The success of waste recycling depends on whether it can be carried out profitably by private enterprises. Some private companies have initiated commercial recycling of polyethylene terephthalate (PET) bottles – a thermoplastic resin of the polyester family that is commonly used to make beverage, water and food containers. The waste management recycling comes at a time when environmentalists are showing a lot of concern over wanton disposal of plastics in sewers, dumping yards and along roads. Plastic waste collection has been extended to urban centres in the Lake Victoria basin such as Kisumu and along major tourist circuits in Masai Mara.

7.8. Alternative energy sources

The main source of energy in the Lake Victoria basin has been woodfuel, leading to fast depletion of forests and related vegetation. Hydro-power generation is limited, although this will expand with the full implementation of the Sondu-Miriu Hydro-power project. Wind power is used mainly to pump water in a few parts of the basin. Hot springs are present in parts of the basin, but these have not been exploited for geothermal energy. Similarly, conversion of solar power to electric energy is below the potential. Oil consumption is particularly for motor-driven engines, cooking and lighting in households. Nationally, Kenya consumes an estimated 514 million tonnes of oil equivalent annually, representing about 18.4 per cent of the total commercial energy consumed in the country. There are no reliable estimates for oil consumption in the Lake Victoria basin. Kenya's energy policy aims at ensuring adequate, quality, cost-effective and affordable supply of energy to meet development needs while protecting the environment. An emerging issue is the development of appropriate technology for increased exploitation of renewable environmentally friendly energy sources such as solar, wind power, biogas and geothermal energy ,to supplement oil and hydro-power,

7.9. Value addition in the primary sectors

It is now recognised that producers in the primary sectors, especially agriculture, livestock and fisheries, may get significantly higher returns through value addition. However, value addition is hampered with under-developed technologies and lack of trained manpower in the field of post-harvest and value-added production. There is need to develop these capacities in regional institutions to train experts in production technologies to increase the benefit from production in the light of dwindling resource base.

7.10. Control of Floods

Flooding has been a persistent problem in the flood plains of Lake Victoria. In particular, the Kano Plains, Lower Nyakach and Budalangi areas are affected by floods from Rivers Nyando, Sondu-Miriu, Yala and Nzoia respectively. There are current attempts to control the impacts of floods by constructing barrier dykes and small dams in the flood prone areas in the basin. The success of these ventures and their negative and positive impacts are yet to be determined.

SECTION 8. ENVIRONMENTAL QUALITY OBJECTIVES

This section describes the major interventions and actions that are technical inputs for consideration by the stakeholders as they develop a strategic action plan.

8.1. Analysis of Environmental Quality Objectives

Environmental Quality Objectives (EQO) were used to develop interventions which were then assigned specific targets achievable over a 5-15 year period. The specific interventions and actions that would lead to achievements of these targets were also identified as shown in the Table 8.1.

The TDA has set three broad Environmental Quality Objectives (EQO), namely;

i) Balanced aquatic ecosystem
ii) Stabilised high quality fresh-water supply
iii) Sustainable land use.

A number of EQO targets have been proposed in this TDA, with a target accomplishment date of 2015. They include;

a) Achieve adequate surface water quality
b) Restore natural surface water flow
c) Achieve sustainable fisheries development
d) Arrest wetland loss
e) Achieve adequate Freshwater quantity
f) Achieve adequate ground water quality and quantity
g) Reduce rate of land degradation by 20%
h) Reduce catchments erosion rates by 25%.

Also included are the activities and the specific interventions to achieve the targets. These targets are in line with the objectives of the Millenium Development Goals. These will improve livelihood status, the environmental situation and ensure sustainable development of the Lake Victoria basin.

Table 8.1 Envirnomental Quality Objectives

Environmental Quality Objective	Targets	Activities	Interventions	Type of Intervention	Root Cause
Balanced Aquatic Ecosystem	Achieve adequate surface water quality by 2015	Establish common methods for assessing water and sediment quality, including bioassays of lake biota	Develop guidelines for methods of water, sediment, and biota monitoring and assessment (including sampling, analysis, risk assessment)	Legislative/Regulatory	Insufficient scientific capacity
			Implement a first periodic assessment (3-year interval) of the river/lake water quality and trends	Investment	
			Develop and establish national/regional land-based activities, sources of contaminant assessment and management	Data management	Insufficient Scientific capacity
		Fill gaps in knowledge of priority pollutants (contaminant input)	Conduct regional assessment of priority land-based activities, sources of contaminants, and pollutant levels in water and sediments	Scientific Investigation	
			Conduct routine targeted monitoring of riverine/lake sediments and biota for purposes of identifying major hot spots of pollution and land-based activities	Investment	
		Exchange environmental data and information	Develop agreements and technology basis for the free and regular exchange of environmental data and information within the region	Data management	Insufficient scientific capacity; Inadequate technical infrastructure
		Reduce impacts of urban areas on water quality	Construct of extend sewage collection systems in all major cities in the basin and routine discharges to treatment		
			Upgrade/renovate existing treatment plants for mechanical and biological treatment		

Environmental Quality Objective	Targets	Activities	Interventions	Type of Intervention	Root Cause
			Expand solid waste (plastics) collection in all major cities and improve disposal methods so waste does not run-off or leach into waterways	Investment	
		Reduce impacts of industry and mining on water	Develop and enforce regulations on the disposal of industries and mining effluents	Legislative/Regulatory	Inadequate legal /regulatory basis; Inadequate institutions; demonstration projects; Inadequate technology
			Strengthen the capacity of institutions to enforce mining and industry regulations	Institutional Strengthening	
			Implement demonstration projects to bring best technology and practice to industrial discharges (e.g. pre-treatment, source control, process control)	Scientific investigation	
		Halt the spread of aquatic weeds by 1015	Improve knowledge of distribution of aquatic weeds using regional groups, SPS?	Scientific Investigation	Insufficient knowledge/understanding; Inadequate legal/regulatory basis; Inadequate lake basin management
			Develop national and regional aquatic weed management strategies /plans/frameworks combined with monitoring and GIS capacities	Policy	
			Establish and implement a control system for the import and export of exotic species into and from the Lake Victoria basin	Legislative/Regulatory	
	Restore natural surface water flow by 2010	Improve water basin management	Agree regionally on extraction of river/Lake water and control outflow	Legislative/Regulatory	Inadequate Water basin management ;Insufficient regional agreements; Inadequate intersect oral coordination

Environmental Quality Objectives	Targets	Activities	***Interventions***	Type of Intervention	Root Cause
			Conduct baseline investigation to establish the minimum threshold required for ecosystem function.	Scientific Investigation	
			Manage water release from hydro-electric dams in accordance with natural requirements	Legislative/ Regulatory	
			Manage water usage for agriculture and other uses in order to maintain more natural river/lake water level and prevent detrimental impact on the ecosystem	Legislative/ Regulatory	
			Develop regional commission with appropriate policy/legal basis to monitor regional water quantity and quality	Policy	
			Implement regional EIA for water management projects, to enhance broad stakeholder involvement in major water projects	Legislative/ Regulatory	
			Develop regional lake basin water management plan of action	Policy	
			Strengthen the capacity of institutions to implement regional basin water management plan of action	Institutional Strengthening	
	Achieve sustainable fisheries development by 2012	Strengthen legal basis	Assure that legislation regulating gear, quotas, size limits, seasons and allowed fishing areas are in place	Legislative/Regulatory	Inadequate legal/regulatory basis Insufficient scientific capacity; Insufficient regional agreements; Inadequate institutions
			Strengthen enforcement of size limits, season, etc., relying on community-based fishery management activities (BMUs)	Policy	
			Help harmonize fishing regulations amongst lake basin countries	Policy	

Environmental Quality Objective	Targets	Activities	Interventions	Type of Intervention	Root Cause
			Strengthen capacity of institutions (Fisheries Department) to enforce fisheries regulations	Institutional Strengthening	
			Establish "no take zones or breeding grounds" either geographically or seasonally	Legislative/ Regulatory	
			Establish criteria for "healthy" fisheries situation	Scientific Investigation	
		Develop site-specific management plans that promote sustainable utilization and protest nursery or reproduction areas	Develop management plans, and implement and monitor then with local communities and user groups	Legislative/ Regulatory	Inadequate legal/regulatory basis; Insufficient economic incentives; Inadequate Institutions
			Strengthen capacity of local communities to implement and monitor management plans	Institutional Strengthening	
		Provide alternative technologies	Develop and demonstrate mechanism to reduce by-catch	Policy	Inadequate Technology
	Arrest wetland loss by 2015	Fill gaps in knowledge of priorities in protecting wetlands	Undertake inventory of selected wetlands sites in the basin to establish extent and condition of habitat and management challenges	Scientific Investigation	Insufficient Scientific capacity; Insufficient knowledge/ Understanding
		Strengthen regional legal basis for protection of wetlands	Review, harmonize, and strengthen relevant local, national, regional, and international legislation and conventions relevant to the conservation and management of wetlands	Legislative/ Regulatory	Inadequate legal/ Regulatory basis; Insufficient regional agreements

Environmental Quality Objectives	Targets	*Activities*	Interventions	Type of Intervention	Root Cause
		Develop management plans for selected wetlands sites of global and ecological importance by 2007	Develop national wetlands management strategies/plans/framework (including community participation and empowerment)	Policy	Inadequate legal/regulatory basis; Inadequate human capacity; Inadequate institutions
			Strengthen the capacity of local conservation groups to conserve wetlands	Institutional Strengthening	
	Prepare and implement Lake biodiversity Conservation strategy by 2015	Develop and implement regional biodiversity strategy	Prepare a regional biodiversity strategy document, including a gap analysis, and obtain endorsement by riparian states	Policy	Insufficient Regional agreement; Inadequate water basin management; Insufficient Knowledge/ Understanding
			Implement biodiversity strategy, including species specific action plans	Scientific Investigation/ Investment	
		Prevention of adverse human activity on sensitive areas	Evaluate sensitivity of areas and habitats in the Volta River basin and evaluate levels of human impacts on them	Scientific Investigation/ Investment	
			If necessary, develop legislation for the protected zones	Legislative/ Regulatory	
			Develop and implement action plans for those sensitive areas where human impact is adverse	Investment	
		Reduce impacts of agriculture, land grazing, and hunting on loss of biodiversity	Implement alternatives to agricultural expansion, unchecked grazing, and poor hunting practices, including bushfires and poaching, to conserve biodiversity	Investment	Insufficient Economic Incentives

Environmental Quality Objective	**Targets**	**Activities**	**Interventions**	***Type of Interventions***	**Root Cause**
Stabilized high-quality freshwater Supplies	Achieve adequate Freshwater quantity by 2015	Rationing of water use through international agreement on shared water basins	Review and strengthen existing regional river system agreement; develop new agreements	Legislative/ Regulatory	Inadequate legal/ regulatory basis; Insufficient knowledge/ understanding Insufficient Economic Inadequate water basin management
			Harmonize environmental and economic policy regarding water use	Policy	
			Monitor supply and quality of water in major rivers	Investment	
			Prepare environmental impact assessments (EAIs) for major investments that may affect water quantity or quality		
			Support freshwater resource tenure and valuation	Investment	
	Achieve adequate ground water quality and quantity by 2015	Fill gaps in knowledge	Develop common guidelines for periodic assessment of groundwater quality and quantity trends	Scientific Investigations	Insufficient scientific capacity; Insufficient Knowledge/ Understanding
			Develop and implement a groundwater quality trend monitoring programme	Investment	
			Conduct the first periodic assessment of groundwater quality and its trends		
			Evaluate sustainable groundwater use rates, and appropriate monitoring systems		
		Improve efficiency and availability of high-quality well water	Based on the sustainable groundwater use rates, improve water extraction and transport systems to rural and urban areas		
			Institute a water use fee structure for all water uses	Investment	

Environmental Quality Objectives	**Targets**	**Activities**	**Interventions**	**Types Intervention**	**Root cause**
		Reduce evaporative losses in drainage basin	Rationalize the use of small dams and barrages for local communities	Policy	Inadequate technical infrastructure
			Revegenerate (reforest, replant) the drainage basin to increase natural evapotranspiration processes	Investment	
Sustainable land use	Reduce rate of land degradation by 20% by 2015	Strengthen regional legal basis for preventing land degradation	National review of policy, legal, and regulatory frameworks, and institutional structure for addressing land-based activities (including international conventions such as climate change)	Legislative/ Regulatory	Inadequate legal/ Regulatory basis; Insufficient regional agreements; Low government priority on environment
			Draft Regional EIA process review in a regional workshops; adopt regional EIA	Legislative/ Regulatory	
			Develop realistic National Plans of Action for land-based sources and activities	Capacity Building	
			Develop common regional guidelines containing appropriate recommendations for decision makers for management of land-based point and non-point pollutant sources	Scientific Investigation	
			Strengthen capacity of institutions to implement National Plans of Action and EIA process review	Insufficient Strengthening	
		Strengthen monitoring capacity for evaluating land degradation rates	Develop a regional commission with appropriate policy/legal basis to monitor regional land degradation	Policy	Insufficient Regional agreements; Inadequate training Inadequate human capacity; Inadequate institutions
			Develop training and educational programs to train regional personnel on monitoring and use of GIS as a planning tool	Capacity Building	

Environmental Quality Objectives	***Targets***	**Activities**	**Interventions**	**Type of Interventions**	**Root causes**
			Develop regional and national institutions to perform ongoing monitoring of land degradation, including geographic areas, causes, and rates	Investment	
			Involve stakeholders, including NGOs and natural resource users, by communicating the results of monitoring and communicating alternative strategies for resource use.		
		Determine and satisfy training needs in region for land-based activities and sources	Conduct survey on training needs and conduct training on land-based activities and sources (for high officials, mid-level government, community, resource users, experts, industry, etc)	Capacity Building	Inadequate training; Inadequate human capacity
			Create community-based agent network to educate and advise stakeholders on alternatives causing land degradation	Investment	
		Develop educational programs at all levels on land-based (LB) activities and sources	Conduct survey on educational needs to support reduction of land-based activities and sources and implement the activities to address three top priority regional educational needs, in appropriate languages	Capacity Building	Insufficient knowledge/understanding ; Inadequate training; inadequate technology
			Develop necessary training at different level on public awareness, applying Best and Cost Effective Technology, Best Agricultural Practices, Integrated Pest Management, increasing irrigation efficiency and fertilizer use, etc.	Capacity Building	
		Develop Regional/ Governmental/ Private Sector partnerships on LB activities and sources	Integrate private sector into activities of this project, as appropriate, as sub-contractor, consultant, or co-sponsor of specific activities	Policy	Insufficient economic incentives

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Interventions	Root cause
		Strengthen legal basis and institutional capacity to reduce impacts of agriculture and animal husbandry	Develop and enforce land use codes for agriculture and animal husbandry	Legislative/ Regulatory	Inadequate legal/ regulatory basis; Inadequate institutions
			Strengthen institutional capacity to support rangeland management; develop community rangelands	Institutional Capacity	
		Develop programs to reduce impact of agriculture and animal husbandry	Riparian countries agree to a list of banned agrochemicals and develop a program to destroy stored banned product	Legislative/ Regulatory	Insufficient regional agreement; Inadequate training; Inadequate legal/ regulatory basis; Inadequate technology; Insufficient scientific capacity
			Riparian countries agree on limits to the application of agrochemicals and develop strategies to encourage the sustainable use of organic manure fertilizer	Legislative/ Regulatory	
			Riparian countries agree on regional controls on bushfires for agriculture, pasturage, and hunting, and enforce the controls	Policy	
			Conduct training courses at farmer and industry level to apply the most appropriate and new findings in their practice by 2015	Capacity Building	
			Strengthen and enforce regulations on the disposal of animal waste	Legislative/ Regulatory	
			Develop more efficient ways to use existing land, increasing yields through better land management, crop rotation, or crop selection	Investment	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Interventions	Root cause
			Develop basin-wide corridors for seasonal migration of livestock through adjacent countries, based on historical common use zones	Policy	
			Develop community-base agricultural/ animal husbandry networks for transfer of technology and best practice	Institutional Strengthening	
			Establish regional and national capacities to monitor, examine causes, and map (using GIS) geographic locations of agriculture and animals husbandry, including protection objectives. Broadly disseminate the results to rural inhabitants	Investment	Inadequate institutions; Insufficient regional agreements; Insufficient knowledge/ understanding; Inadequate legal/ regulatory basis; Insufficient economic incentives; Inadequate training; Insufficient scientific capacity
		Establish and maintain a network of well-managed protected area in the lake victoria basin	Establish a functioning regional protected area working group for protection and management functions, financial arrangements, recommending new protected area and addressing management of protected area located along international borders	Institutional Strengthening	
			Obtain government endorsement for the recommended protected areas	Policy	
			Evaluate the priority targets for protection in each protected area and how these fit into regional priorities	Scientific Investigation	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Interventions	Root cause
			Review and propose revisions for national legislation on protected area to permit environmentally friendly use of the protected areas	Legislative/ Regulatory	
			Allocate a zone within protected areas or adjacent to them for eco tourism activities	Legislative/ Regulatory	
			Provide training in national protected area management of eco tourism	Capacity Building	
			Reduce poaching in protected areas by ensuring that legislation regulation hunting are strengthened and enforced.	Legislative/ Regulatory	
			Increase stakeholder participation, including community ownership, of protected areas	Capacity Building	
			Establish regional and national capacities to monitor, examine causes, and map (using GIS) geographic locations of protected areas, including protection objectives. Broadly disseminate the results to rural inhabitants.	Investment	
		Reduce rate of deforestation	Identify main contributors to deforestation, including public and private sector, as well as legal and regulatory failures	Scientific Investigation	Insufficient demonstration project Insufficient economic incentive; Insufficient knowledge/ understanding; Inadequate legal/ regulatory basis; Inadequate human capacity
			Identify alternative sources for products historically produced from forests and link with appropriate incentives and disincentives	Scientific Investigation	
			Identify means to increase efficiency and reduce waste in use of forest products, through demonstration projects	Investment	
			Strengthen legislation to reduce rate of deforestation based on economic incentive and disincentives	Legislative/ Regulatory	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Interventions	Root cause
			Strengthen reforestation program and begin their implementation in affected areas, at village, community, and regional levels	Investment	
			Establish regional and national capacities to monitor, examine causes and map (using GIS) rate and geographic locations of deforestation and reforestation. Broadly disseminate the results to rural inhabitants.	Investment	
		Reduce rate of loss of land to desertification	Increase awareness of local populations of the desertification process, perhaps working through existing mechanisms	Capacity Building	Insufficient knowledge/ understanding; Inadequate legal/ regulatory basis; Insufficient scientific capacity; Insufficient demonstration projects
			Improve legal basis in each country for combating desertification, including: criteria to define land degradation; amended law on forestry, water resources and land, and strengthened legal mechanisms such as EIA and planning procedures	Legislative/ Regulatory	
			Develop a desertification monitoring system and widely disseminate result	Capacity Building	
			Demonstrate ways to reverse desertification	Investment	
		Reduce land degradation due to mining, stone quaring, brick making	Evaluate national legislation addressing mining and use of non-living resources	Scientific Investigation	Inadequate legal/ regulatory basis; Inadequate intersectoral coordination; Insufficient regional agreements; Insufficient demonstration projects
			Create regional working group on land degradation due to mining, and recommend specific common regional improvements to policy and legislation	Policy	
			Implement recommendations of regional working group in national laws and regulations	Legislative/ Regulatory	

Environmental Quality Objectives	Targets	Activities	Interventions	Type of Interventions	Root cause
			Perform demonstration projects of ways to avoid adverse environmental impacts of mining	Investment	
		Develop culturally-adopted improvements to land tenure system/property rights in the region	Perform investigation of the policy, legal, and cultural basis for land tenure policies in the lake basin	Scientific Investigation	Inadequate legal/ regulatory basis; Insufficient economic incentives
			Develop more effective methods of land tenure to reduce tendency for migration to fresh lands, and to encourage "investment" in lands (e.g. efficient irrigation improved crop methods)	Policy	
			Implement environmentally sustainable land tenure system in the region, perhaps as " special planning zone"	Investment	
	Reduce catchments erosion rates by 25% by 2015	Fill gap in knowledge	Conduct assessment of effects of farming on coastal erosion on the catchments	Scientific Investigation	Insufficient knowledge/understanding
		Develop catchments erosion management plan through a participatory process	Promote environmental and community-based tourism	Capacity Building	Insufficient economic incentive; Inadequate human capacity
		Strengthen legal basis for protection of coastline	Review harmonize and strengthen relevant local and national policies and legislation regarding coastal zone and river basin management	Legislative/ Regulatory	Inadequate legal/ regulatory basis; Inadequate intersectoral coordination

SECTION 9. SUMMARY AND CONCLUSION

9.1 This Transboundary Diagnostic Analysis (TDA) of the Lake Victoria basin has generated a wealth of information in relation to the situation in the catchment, underlying problems and issues and potential interventions. TDA is a scientific and technical assessment through which transboundary water-related environmental and economic issues and problems are identified and quantified, their causes analysed and impacts assessed. The analysis involves an identification of causes and impacts of issues at defined boundaries, including; local, national, regional and global levels paying attention to the socio-economic, legal, political and institutional context within which they occur. This involves identification of the root causes, specific sources, locations and sectors.

9.2 Data and information for this TDA has been collected through; desk review of relevant literature and analysis of empirical data, information gathering through questionnaires and interview of stakeholders, as well as the validation of the main findings and the acquisition of new information through conducting various local and national meetings and workshops. A key input was the stakeholders workshop held in Nairobi on 24th March 2006. The TDA process has involved close consultation with the client (MENR/LVEMP-II) throughout the study.

9.3 In conducting this TDA, the Global International Waters Assessment (GIWA) model was used, which involved of scaling, scoping, causal chain analysis and policy options analysis. This model has enabled the identification of the major perceived problems and issues (MPPI), analyses of information generated and formulation of remedial measures as required in a TDA process. Subsequently, a causal chain analysis was undertaken for each Major Perceived Problems and Issues (MPPI). Additionally Participatory Rural Appraisal (PRA) has been used in this TDA study to prioritize the MPPI from the perception of the main primary sector groups such as fishers, farmers and women groups.

9.4 The TDA has identified the main primary productive sectors in the Lake Victoria basin as; Land, water, agriculture, livestock, fisheries, forests, wetlands, mining, energy, wildlife and tourism (cultural sites).

9.5 Fisheries constitute one of the most important resources of the lake basin, with a production value in Kenya estimated at about $88 million and an export value of $60 million, and additional benefits as source of protein and employment as well as source of raw material for fishmeal industry. Fisheries contribute about 0.5% of Kenya's GDP, and a much higher percentage of the Lake Victoria basin GDP, although the latter has not been determined. Lake Victoria is Kenya's dominant fish source, producing about 92% of landed fish. There are three commercial fish species of Lake Victoria; Nile perch (*Lates niloticus*), Nile tilapia (*Oreochromis niloticus*) and 'dagaa' (*Rastrineobola argentea*), which constitute over 95% of total fish catch.

9.6 Agriculture contributes about 24% of Kenya's Gross Domestic Product (GDP) and provides employment to over 75% of the population, particularly those living in the rural areas, and contributes over 70% of raw materials for agro-processing and 45% of government revenues. It is also a major foreign exchange earner. Agricultural production is one of the mainstays of the lake basin economic base. The main food crops include; maize, beans, rice, cassava, sweet potato, Irish potato, sorghum, wheat, millet, banana, pineapples, groundnuts, simsim, cowpeas, green grams, soybeans, tomato and a wide variety of indigenous and exotic fruits, vegetables and other horticultural crops. The main cash crops are; sugar cane, tea, coffee, pyrethrum, tobacco, sunflower, cotton and pyrethrum.

9.7 The major issues in Agricultural sector include low production due to unpredictable weather patterns, low fertility of the soils, non-adoption of modern technology,and high incidences of crop pests and high population pressure on the land due to diminishing land parcels as they get subdivided due to inheritance. Agricultural production in Kenya is also affected by cross-border trade of agricultural products. There is need to enhance environmental conservation measures along with farming practices in the form of soil conservation, riverbank protection and conservation, water harvesting and management, and agro-forestry practices.

9.8 The livestock industry accounts for 7% of GDP and is based mainly on cattle, goats, sheep, pigs and poultry. The main products are milk products (milk, ghee etc.), meat products (beef, mutton, chicken etc.), eggs, hide and skin. There are about 1.5 million cattle within the catchment and a high number of local breeds of goats and sheep within the catchment. The main cattle in the lake basin are indigenous Zebu breeds, but increasingly there are cross-breed (and few pure breeds) dairy herds. The small East African goat, sheep and poultry also play a major economic role. The major livestock diseases in the basin are; Trypanosomiasis, East Coast Fever, Anaplasmosis, Babesiosis, Heartwater, Newcastle disease, Foot and mouth disease, Rift Valley fever, rabies, etc.

9.9 To improve the livestock sector there is need to develop clear policy on milk production, processing and marketing; promote animal health by reactivating and expanding dipping, breeding and veterinary services; promote dairy goats as an emerging source of milk and other small stock activities such as poultry and bee-keeping; support the development of facilities for milk handling such as collection and cooling centres; encourage the private sector and local authorities to establish small abbartoirs and meat processing facilities; and encourage the establishment of value adding processes. There is need to minimise inbreeding within herds; control stocks in rangeland, provide and maintain watering points.

9.10 Forests contribute immensely to the basin's economy by providing wood and non-wood forest products for commercial and domestic use. The wood products support the pulp and paper industries, sawmills, the building and construction industry, charcoal and firewood production and transmission posts for telephone and electricity lines. Non-wood products and services include; woodcarving, beehives, wildlife sanctuary, cultural and tourist sites. Forests also provide fruits and nuts, medicinal plants, wild vegetables, water

and fish. The main objectives for forestry management are for timber production, conservation of biological diversity, watershed management or multiple use management. However,forestry, has been accorded low priority in overall national economic planning and resource allocation in comparison to other sectors such as health, education and agriculture.

9.11 The main sources of energy in Kenya are wood fuel, electricity and oil. Nationally, wood fuel accounts for 70%, while oil and electricity constitute 20% and 9% of Kenya's energy consumption. In the lake basin, hydro-power electricity generation is limited, although this will expand with the full implementation of the Sondu-Miriu Hydro-power project. Other potential energy sources such as solar, geothermal and wind energy are not significantly developed. Wind power is used mainly to pump water in a few parts of the basin and to propel sail boats in the lake. Hot springs are present in parts of the basin, but these have not been exploited for geothermal energy. Similarly, conversion of solar power to electric energy is least exploited.

9.12 Mining contributes about 2% of the national Gross Domestic Product. In the Lake Victoria basin, mining takes place in isolated areas, however, its contribution to the basin economy has not been determined. Gold has been the main industrially mined mineral in the basin, however, most of the major identified gold mines, for example, in Migori and Kakamega districts, have been fully exploited and there is little industrial mining now taking place. Other minerals are copper, base metals, rare earth elements, Kisii soapstone, phosphate, sulfur, Wollastonite and nephelinite, manganese, tin, kaolin, clay, flourspar, iron ore, graphite, sheltie, diatomaceous soil, and building material (limestone, granite, brick clay, sand, tuffs, murrum and material for ballast). Industrial mining of limestone continues at Koru in Nyando District. There is some artisanal mining activity going on, especially for gold, the extraction of building material, such as granite, brick clay, sand, tuffs, murrum and material for ballast. There is need for increased exploration for new mineral deposits that may be commercially exploited.

9.13 Some of the important and famous gazetted National Parks, such as Masai Mara, Mt. Elgon and Ruma are within the Lake Victoria basin. However, the immediate Lake Victoria circuit (the so-called 'Western Tourist Circuit') is perceived to be of high tourist potential, though, still not well developed. Efforts to develop tourism in the region should target; the beautiful landscape, the people, sacred and cultural sites (for example 'Nyamgondho' in Suba District and 'Thim Lich Ohinga' in Migori District), pre-historic sites (for example palaentological sites in Rusinga Island), and pre-colonial fortified sites; indigenous forests (for example, in Kakamega); the lake, islands, and lake resources (including ornamental fish); wild game, including insects (for instance, butterfly in Kakamega Forest) and numerous natural features (including famous rocks such as 'Kit Mikayi' in Kisumu District) and hot springs (in Rachuonyo District). There are also Museums maintained by the National Museums of Kenya, for example in Kisumu and Kitale, which are an integral part of the tourist circuit. There is need to improve the infrastructure, provision of services and amenities for the tourist industry to develop.

9.14 The TDA identified a number of transboundary major perceived problems and issues (MPPI) and analysed their impacts. The analysis involved assessment of the root causes, specific sources, locations and sectors for each MPPI. The identified MPPI are; Decline in certain endemic and commercial fish stocks; Threats to biodiversity; Overall declines in environmental quality (water quality and sedimentation); Climatic change/ variability; Degradation of catchments landscapes and damage to catchments habitats; Invasive and introduced species; Deteriorating infrastructure and amenities; Decline in human health; Conflicts in resource use and floods in parts of the Lake basin.

9.15 There has been a general decline in the major commercial fish species in Lake Victoria, including; Nile perch, Tilappiines and Dagaa. The main causes of fisheries decline are: Habitat degradation; Lack and/or mis-management of fisheries, leading to overexploitation; Worsening geopolitical and economic climate causing negative impacts such as poor enforcement of, and compliance with, fishing regulations; Open access policy, thus increased fishing pressure by jobless lakeside communities; Insufficient scientific knowledge of how fish species may adapt to changing Lake Victoria environment; Possible eutrophication effects on plankton, in some river deltas/mouths and near the urban discharges e.g Kisat River; Lack of alternative livelihoods and poverty.

9.16 There is concern over widespread loss of biodiversity in Lake Victoria (at species, genetic, and habitat levels). Most affected are fisheries, forestry and a range of wild fauna and flora. The high rate of species endemism in Lake Victoria basin would suggest that biodiversity may be particularly sensitive to threats from industrial pollution, over fishing, invasion of exotic species, and other human activities. The major factors threatening decreased biodiversity of the basin are; Interference with inflowing rivers and water destruction; Illegal fishing and over-fishing; Water level changes; Pollution; Invasive and Introduced species; Climate change; Deforestation through cutting of trees and grass for charcoal and brick burning; Illegal hunting and poaching; open access policy to most natural resources.

9.17 There has been an overall decline in environmental quality. The main environmental components of concern are; air and water quality. Air pollution mainly results from emission from factories. The main issues in relation to water quality are; Discharge of agro-chemicals into rivers and lakes; Persistent Organic Pollutants (POPs), Biological Oxygen Demand (BOD), High levels of faecal coliforms and disposal of domestic and industrial wastes. The main causes of water pollution are; Improper use of agro-chemicals on farms; Improper runoff and drainage systems; Discharge of raw/untreated sewage into rivers/lakes. The rapidly growing urban and peri-urban centres located within the catchment of Lake Victoria basin have contributed to increased environmental degradation through uncontrolled municipal and industrial effluents from the breweries, textile dyeing, tanning, fish and agro-processing industries, which pollute the rivers and the lake (UN-HABITAT, 2005). The Lake has experienced a decline in water quality since the 1960s. For instance, phosphorus concentrations and algal biomasses have increased significantly, leading to filamentous and colonial blue-green algae dominating

the algal community (Lunga'yia *et al*. 2000; Kling *et al.* 1998). The polluted state of the lake also resulted in water hyacinth invasion in the mid to late 1990s. Paper and sugar industries within the catchment of Lake Victoria are major cause of concern due to their discharges to the river flowing into Lake Victoria. There has been an outcry over the discharge of chlorine and offensive sludges into rivers within the basin. Sedimentation is also another concern.

9.18 The TDA has reported that there has been climatic variability and change that has contributed to the current condition of Lake Victoria. The Lake's status has apparently been influenced by the global warming trend evident in the high-elevation tropics as well as increased particulate organic matter in the water column. The driving mechanism seems to be anomalously high sea surface temperatures in the tropical ocean persisting for at least 30 years, about the time frame during which Lake Victoria has experienced its most dramatic changes. The Lake is now 0.5℃ warmer than in the 1960s, in harmony with changes in surface temperature at tropical elevations above 1000 m worldwide (Lehman, 1997). Changes in radiative heat transfer functions have led to elevated water temperatures. Slackened winds have caused less intense mixing, enhancing the anoxic conditions in the hypolimnion. The different types of climate change are drought, floods, hurricanes, cyclones, tsunami, increased cloud cover and precipitation. Changes in climate can induce long-term, low-grade and cumulative or short-term and abrupt alterations to the environment. Climate change can alter the abundance, distribution and availability of fish, livestock and range animals. Climate variability may cause variation in the farming seasons, hence affecting crop production. Climate variability may interfere with the regeneration of animal populations. Thus, some of the common manifestation of climatic change in the Lake basin are; temperature rise (global warming), flooding, changing rainfall pattern, severe droughts, increase in severe weather events e.g. *el nino* etc. The main causes of climate changes are emissions of carbon dioxide; and deforestation.

9.19 The TDA has reported huge degradation of catchment landscapes. The lake basin has lost a large portion of its vegetative cover and soils. This has caused damage to the catchment habitat and degradation of landscape. The immediate causes are deforestation, soils erosion, poor farming practices and overstocking livestock. Inadequate compliance with and enforcement of legal regulations, weak economic situations, absent or inadequate national and regional EIA processes, population growth and inadequate public awareness are the underlying causes. The most critical issues in forestry management and conservation include; Lack of integration forestry into larger land use policies or environmental policies; Lack of protection to maintain integrity of forests; Lack of protection and conservation of biological diversity; Inadequate legislation to support transboundary control of forests;; Royalties and fees in forestry are low; Ban on logging in indigenous forests; There is no mechanism in place to certify forestry products that are produced.

9.20 Lake Victoria basin has experienced invasive and introduced species over the years. The most adverse invasive species in the Lake Victoria basin are; Nile

perch, water hyacinth and striga weed. Nile perch was introduced into Lake Victoria from Lakes Albert and Turkana during the 1950s and 1960s to compensate for depleting commercial fisheries, by converting low-value haplochromines into higher-value and more easily captured fish population. As Nile perch increased, there has been a drastic decline in populations of many indigenous species. Particularly devastating was the disappearance of more than 50% of the non-littoral haplochromine cichlids or about 40% of the endemic haplochromine population. The species changes in Lake Victoria are notable from the 1950s through the 1970s and the 1990s, and the food web in Lake Victoria also changed significantly as a result of introduction of Nile perch. Water hyacinth is a flowering plant introduced into Lake Victoria through River Kagera. The weed doubles in mass in 11-18 days. It is free floating and migratory or submerged, depending on the sub-strata. It is sustained in Lake Victoria through high nutrient input from the catchment. Water hyacinth reduced the efficiency of operation of the Owen Falls hydroelectric plant and blocked access to ports, fish landings and watering points. It interfered with fishing operations, fishing boats and gears, recreational activities and commercial transportation services for people and goods. It led also to increased water loss through excessive evapotranspiration, destruction of fishing grounds through lack of light, nutrients and oxygen and provided favorable habitat for disease vectors. By 1998 the weed occupied over 17,000 ha and nearly 90% of shoreline in Kenya (Othina *et al*. 2003; Njiru *et al*. 2002). The other invasive weeds in the lake basin include; striga, duck weed, *Lantana camara*, African marigold, *Solanium nigrum*, Mexican marigold etc. Striga has the greatest adverse impact on agricultural productivity among the invasive weeds.

9.21 There have been problems with transboundary transport infrastructure. The main means of transboundary transport are by road, water and air. There is presently no cross-border rail transport in the region, however, there are long-term plans to revive the East African rail network. Road transport is mainly through the main international transit routes passing through the official border posts, for example; Nairobi-Kisii-Isebania, Nairobi-Kisumu-Busia, Nairobi-Eldoret-Malaba and Busia-Kisumu-Isebania. There are also numerous smaller roads or tracks across porous borders. It has been recommended that a ring-road be developed to run along the Kenyan shoreline, joining most fish landing beaches, which would greatly improve communication and fish trade. Transboundary public road transport vehicles include buses, mini-buses and small vans, while there are numerous smaller private cars and larger vehicles transporting goods, including oil tankers. The road infrastructure in the lake basin is, however, one of the least developed in Kenya, particularly in the area immediately around the lake. Most roads in the area are not permanent, made mainly of murram and gravel, which require very frequent maintenance. Many of these roads are impassable during the rainy seasons, causing serious disruption on movement of people and goods and imposing huge costs on providers of transport services. Another emerging type of public road transport is by bicycle taxi, popularly known as 'boda boda'. These are found in nearly all the major towns and rural centres, contributing significantly to employment of young people. The bicycle transport is now a major, though informal, player in the transport sector in both urban and rural centres. The bicycle taxi services extend to the major transboundary areas, including the official border

posts and the unofficial cross-border routes in the region. The main problems facing bicycle transport are; lack of rules and regulation, no bicycle tracks, high rates of accidents, untrained operators etc. The Lake water is a medium of transport especially for communities living around the lake and in several islands within. There are several small passenger and goods transport boats operating very informally in the lake with hardly any regulation, and a few large regional cargo transport vessels operated by the national Railways and Harbour Corporations in the three countries. However, there is little data and information available on the volume and value of this transport industry. The main problems in relation to water-based transport are; lack of regulation, high rates of accidents, no disaster preparedness, and poor facilities and services. Air transport is limited to the main cities, and connects the two main airports in Eldoret and Kisumu to the outside world, via Nairobi. Eldoret Airport is fully fledged international airport, however, the location and altitude makes it less attractive to potential users. It has been indicated that the Kisumu Airport is more strategically located and can attract much larger volume of business. Therefore it is recommended that Kisumu Airport should be upgraded to an international airport, which will necessitate additional investment in upgrading the infrastructure, facilities and services. Kisumu airport is a potential means to drive the growth of the fish and horticulture export industries in the region. However, due to their central location, the airports do not sufficiently serve the needs of the greater Lake Victoria basin. In particular, the fish industry has not benefited from the airports, instead preferring to transport fish to Nairobi and Mombasa by road for export.

9.22 The lake basin is prone to serious human, livestock and crop diseases and pests. The lake basin faces serious challenges in health and socio-economic development. According to the 1999 Kenya National Population Census, the lake basin has very high infant mortality rate, with about 90 children out of 1000 expected to die before reaching the age of 5. The life expectancy in the lake basin stands at 49.2 years for males and 55.2 years for females. Both figures are lower than the national average, which stands at 52.8 years for males and 60.4 for females. The mean age in the lake basin is quite low, at 16.8 years, compared to 18.3 years national average. Unemployment rates are quite high in the basin, where only 19.7% of the population is in active employment, compared to 27.9% national average. At the Lake's shores the incidence of malaria is amongst the highest in the world, closely followed by HIV/AIDS. The major human diseases are; HIV and related illnesses (HIV/Aids, Tuberculosis, Upper respiratory infections, Meningitis, Pneumonia, Anaemia), Vector-borne diseases (Malaria, Schistosomiasis, Trypanosomiasis), Water-borne diseases (Typhoid, Cholera, Amoebiasis). The most common animal diseases within this region are Trypanosomiasis, East Coast Fever, Anaplasmosis, Babesiosis, Heartwater, Newcastle disease, Foot and mouth disease, Rift Valley fever, rabies etc. Livestock diseases have been the major challenges to pastoralism. Wild animals are a major factor in the spread of these diseases. The concentration of livestock within relatively smaller areas means that diseases can spread quickly. Livestock movement is identified as one mechanism for the spread of diseases and as a constraint which make control and eradication very difficult Thus, the situation could be improved by separating domesticated animals from bush animals

and by vaccination. In the recent past much media publicity has been given to the avian influenza (H5N1), however, there have not been any confirmed cases in the Lake Victoria basin.

9.23 There have been persistent resource use conflicts in the Lake Victoria basin. In the recent past, the Lake has witnessed conflicts in resource use, including; cattle rustling, access rights, cross-border fishing, water use, wetlands degradation, forest destruction, wildlife migration and increased incidences of bush fires. Clearing of forests has resulted into deforestation, a dominant feature in most parts of the lake zone where land is bare following the expansion of settlements, livestock keeping and agriculture. There are also conflicts in opinion regarding management, conservation and use of natural resources between various groups, for example; scientists versus political leaders, fisheries managers versus fisheries biologists, politicians versus politicians and between different groups of resource harvesters. Ultimately this affects decisions and strategies on how resources are utilized, with the result that it is often difficult to reach a consensus among different and competing interest groups. The degree of dependence of a community or a country on the commercial exploitation of a particular resource could be the key to understanding the major determinant in the resolution of a conflict over the resource. The main reasons for conflicts include the following; Cattle rustling; Diversion of river course; Unmarked boundary/ disputes over boundaries; Cross-border fishing,declining fish stocks and competition for Nile perch; Bush fires; Wetlands degradation; Water decline and Forest destruction.

9.24 Flooding is a persistent problem in the flood plains of Lake Victoria. In particular Kano Plains, Lower Nyakach and Budalangi areas are flooded annually during long rains, and even sometimes also during short rains. The major rivers flowing into Lake Victoria that are prone to cause floods are rivers Nyando, Sondu-Miriu, Yala and Nzoia. The joint Migori/Kuja river also occasionally flood their estuary, but because of low population density in the river mouth, the impact is low. Floods cause disruption to livelihoods and cause families to incur unexpected costs, which is usually very high. It includes the costs of settlement in new areas and resettlement back in their homes after floods recede. Usually the houses themselves are brought down by floods and new ones have to be re-constructed after floods. Affected families have to move out of their homestead to higher grounds; in the process they lose their household property and livestock. In addition it is quite demeaning since families have to depend on food donations. Farming and other economic activities are also seriously disrupted when people have to move out of their farms in affected areas. Commonly floods destroy crops on the farm, causing farmers to miss the whole planting season. Floods destroy infrastructure, social amenities and degradation of landscape through soil erosion. Flooded areas are also prone to water-borne and water-related diseases such as Malaria, Bilharzia and intestinal infections. The major reason for persistent flooding problem is that there has been little or no attempt to control or manage floods. Current attempts to reduce impacts of flooding include constructing barrier dykes and small dams in areas prone to flooding. These are very recent initiatives in the Lake Victoria basin and their impact has not been evaluated.

9.25 A stakeholder analysis has been carried to provide a description of all the stakeholders, including institutions, organisations, ministries, and industry related to the perceived problem and issues.The information pertaining to this list includes the effect of the on stakeholders, the nature and effectiveness of the interactions between the stakeholders as well as their strengths and weaknesses in view of their actual and /or potential role in managing water and water dependent resources. Among the key category of stakeholders are:Ministries of Environment and Natural Resources, Agriculture, Tourism and Wildlife, Livestock and Fisheries; National research institutions, including, KMFRI, KARI, KEFRI, KIRDI; NGOs, and universities; Primary stakeholder groups in fisheries, agriculture, forestry etc.; and Industries, among others.

9.26 There are a number of emerging issues identified in this TDA. They include; Changes in the lake levels; Avian flu; Bioavailability of nutrients; Negotiating the Nile Treaty; Highland Malaria; The Eucalyptus pest (Blue Gum Chalcid); Recycling of solid waste; Developing alternative energy sources; Value addition in the primary productive sectors, and controlling floods in the lake basin.

9.27 The TDA sets three broad Environmental Quality Objectives (EQO), namely; A balanced aquatic ecosystem; Stabilised high quality fresh-water supply, and; Sustainable land use. A number of EQO targets have been proposed in this TDA, with a target accomplishment date of 2015. They include; Achieve adequate surface water quality; Restore natural surface water flow; Achieve sustainable fisheries development; Arrest wetland loss; Achieve adequate Freshwater quantity; Achieve adequate ground water quality and quantity; Reduce rate of land degradation by 20%; Reduce catchments erosion rates by 25%. Also included are the activities and the specific interventions to achieve the targets. These targets are in line with the objectives of the Millenium Development Goals. These will improve livelihood status, the environmental situation and ensure sustainable development of the Lake Victoria basin.

SECTION 10. RECOMMENDATIONS

This TDA recognises the need to have a balanced aquatic system, stabilised high quality fresh-water supply and sustainable land use. For these to be achieved specific actions will have to be taken targeting the key sectors, namely; water, solid waste management, disaster preparedness, invasive species, fisheries, wetlands, biodiversity conservation, land use, energy, mining and forestry. The following are the recommendations for the key sectors;

10.1. Water Sector

10.1.1. Water quality

i) Establish an Environmental Toxicology referral laboratory to generate information on human and environmental risk assessment studies
ii) Establish common methods for assessing water and sediment quality, including bioassays of lake biota
iii) Fill gaps in knowledge of priority pollutants (contaminant input)
   a) Develop guidelines for methods of water, sediment, and biota monitoring and assessment (including sampling, analysis, risk assessment)
   b) Implement a first periodic assessment (3-year interval) of the river/lake water quality and trends
   c) Develop and establish national/regional land-based activities, sources of contaminant assessment and management
   d) Conduct regional assessment of priority land-based activities, sources of contaminants, and pollutant levels in water , sediments and biota
   e) Conduct routine targeted monitoring of riverine/lake sediments and biota for purposes of identifying major hot spots of pollution and land-based activities
   f) Develop agreements and technology basis for the free and regular exchange of environmental data and information within the region
   g) Reduce impacts of urban areas on water quality
   h) Develop innovative monitoring and evaluation system

10.1.2. Water quantity

i) Achieve adequate Freshwater quantity
ii) Ration water use through international agreement on shared water bas
   a) Review and strengthen existing regional river system agreement; develop new agreements
   b) Harmonize environmental and economic policy regarding water use
   c) Monitor supply and quality of water in major rivers
   d) Prepare environmental impact assessments (EAIs) for major investments that may affect water quantity or quality
   e) Support freshwater resource tenure and valuation
   f) Construct water reservoir/dams along flood prone rivers for domestic/animal/irrigation use
iii) Achieve adequate ground water quality and quantity
iv) Fill gaps in knowledge

a) Develop common guidelines for periodic assessment of groundwater quality and quantity trends
b) Develop and implement a groundwater quality trend monitoring programme
c) Conduct the first periodic assessment of groundwater quality and its trends
d) Evaluate sustainable groundwater use rates, and appropriate monitoring systems

v) Improve efficiency and availability of high-quality well water
   a) Based on the sustainable groundwater use rates, improve water extraction and transport systems to rural and urban areas
   b) Institute a water use fee structure for all water uses
vi) Reduce evaporative losses in drainage basin
vii) Rationalize the use of small dams and barrages for local communities
viii) Revegenerate (reforest, replant) the drainage basin to increase natural evapotranspiration processes
ix) Develop innovative monitoring and evaluation system

10.1.3. Water basin management

i) Agree regionally on extraction of river/Lake water and control outflow
ii) Conduct baseline investigation to establish the minimum threshold required for ecosystem function.
iii) Manage water release from hydro-electric dams in accordance with natural requirements
iv) Manage water usage for agriculture and other uses in order to maintain more natural river/lake water level and prevent detrimental impact on the ecosystem
v) Develop regional commission with appropriate policy/legal basis to monitor regional water quantity and quality
vi) Implement regional EIA for water management projects, to enhance broad stakeholder involvement in major water projects
vii) Develop regional lake basin water management plan of action
viii) Strengthen the capacity of institutions to implement regional basin water management plan of action
ix) Develop a water resources management master plan
x) Pursue ecosystem management of Lake Victoria basin
xi) Increased research on water basin management
xii) Develop innovative monitoring and evaluation system

10.2. Solid waste management

i) Construct of extend sewage collection systems in all major cities in the basin and routine discharges to treatment
ii) Upgrade/renovate existing treatment plants for mechanical and biological treatment
iii) Expand solid waste (plastics) collection in all major cities and improve disposal methods so waste does not run-off or leach into waterways
iv) Develop biodegradable packaging materials
v) Reduce impacts of industry and mining on water

vi) Develop and enforce regulations on the disposal of industries and mining effluents
vii) Strengthen the capacity of institutions to enforce mining and industry regulations
viii) Implement demonstration projects to bring best technology and practice to industrial discharges (e.g. pre-treatment, source control, process control)
ix) Develop innovative monitoring and evaluation system.

10.3. Disaster Preparedness

i) Put in place Disaster Management measures
ii) Operationalise the Toxic Chemical/Oil Spill Contingency Plan prepared under LVEMP I.
iii) Develop innovative monitoring and evaluation system.

10.4. Invasive Weeds Management

i) Halt the spread of aquatic weeds
ii) Improve knowledge of distribution of aquatic weeds using regional groups,
iii) Develop national and regional aquatic weed management strategies /plans/frameworks combined with monitoring and GIS capacities
iv) Establish and implement a control system for the import and export of exotic species into and from the Lake.
v) Develop innovative monitoring and evaluation system.

10.5. Fisheries Sector

i) Assure that legislation regulating gear, quotas, size limits, seasons and allowed fishing areas are in place
ii) Strengthen enforcement of size limits, season, etc., relying on community-based fishery management activities (BMUs)
iii) Help harmonize fishing regulations amongst lake basin countries
iv) Strengthen capacity of institutions (Fisheries Department) to enforce fisheries regulations
v) Enforce Sanitary and Phytosanitrary Standards (SPS)
vi) Establish “no take zones or breeding grounds” either geographically or seasonally
vii) Establish criteria for “healthy” fisheries situation
viii) Develop site-specific management plans that promote sustainable utilization and protect nursery or reproduction areas
    a) Develop management plans, and implement and monitor then with local communities and user groups
    b) Strengthen capacity of local communities to implement and monitor management plans
ix) Provide alternative technologies
    a) Develop and demonstrate mechanism to reduce by-catch
    b) Develop and promote appropriate fish culture species and systems
    c) Develop and promote Value - added fishery products
x) Develop innovative monitoring and evaluation system

10.6. Wetland Sector

i) Arrest Wetland Loss
ii) Fill gaps in knowledge of priorities in protecting wetlands
   a) Undertake/review inventory of selected wetlands sites in the basin to establish extent and condition of habitat and management challenges

iii) Strengthen regional legal basis for protection of wetlands
   a) Review, harmonize, and strengthen relevant local, national, regional, and international legislation and conventions relevant to the conservation and management of wetlands

iv) Develop management plans for selected wetlands sites of global and ecological importance.
   a) Develop national wetlands management strategies/plans/framework (including community participation and empowerment)

10.7. Biodiversity Conservation

i) Develop and implement regional biodiversity strategy
   a) Prepare a regional biodiversity strategy document, including a gap analysis, and obtain endorsement by riparian states
   b) Strengthen the capacity of local conservation groups to conserve wetlands

ii) Prevention of adverse human activity on sensitive areas
   a) Evaluate sensitivity of areas and habitats in the Lake Victoria basin and evaluate levels of human impacts on them
   b) Implement biodiversity strategy, including species specific action plans
   c) If necessary, develop legislation for the protected zones
   d) Develop and implement action plans for those sensitive areas where human impact is adverse

iii) Reduce impacts of agriculture, land grazing, and hunting on loss of biodiversity
   a) Implement alternatives to agricultural expansion, unchecked grazing, and poor hunting practices, including bushfires and poaching, to conserve biodiversity

10.8. Land Use

i) Reduce rate of land degradation by 20% by 2015
ii) Strengthen regional legal basis for preventing land degradation
   a) National review of policy, legal, and regulatory frameworks, and institutional structure for addressing land-based activities (including international conventions such as climate change)
   b) Draft Regional EIA process review in a regional workshops; adopt regional EIA
   c) Develop realistic National Plans of Action for land-based sources and activities
   d) Develop common regional guidelines containing appropriate recommendations for decision makers for management of land-based point and non-point pollutant sources

iii) Strengthen capacity of institutions to implement National Plans of Action and EIA process review
   a) Strengthen monitoring capacity for evaluating land degradation rates
   b) Develop a regional commission with appropriate policy/legal basis to monitor regional land degradation
   c) Develop training and educational programs to train regional personnel on monitoring and use of GIS as a planning tool
   d) Develop regional and national institutions to perform ongoing monitoring of land degradation, including geographic areas, causes, and rates
   e) Involve stakeholders, including NGOs and natural resource users, by communicating the results of monitoring and communicating alternative strategies for resource use.

iv) Determine and satisfy training needs in region for land-based activities and sources.
   a) Conduct survey on training needs and conduct training on land-based activities and sources (for high officials, mid-level government, community, resource users, experts, industry, etc)
   b) Create community-based agent network to educate and advise stakeholders on alternatives causing land degradation

v) Develop educational programs at all levels on land-based (LB) activities and sources
   a) Conduct survey on educational needs to support reduction of land-based activities and sources and implement the activities to address three top priority regional educational needs, in appropriate languages
   b) Develop necessary training at different level on public awareness, applying Best and Cost Effective Technology, Best Agricultural Practices, Integrated Pest Management, increasing irrigation efficiency and fertilizer use, etc.

v) Develop Regional/ Governmental/ Private Sector partnerships on LB activities and sources
   a) Integrate private sector into activities of this project, as appropriate, as sub-contractor, consultant, or co-sponsor of specific activities

vi) Strengthen legal basis and institutional capacity to reduce impacts of agriculture and animal husbandry.
   a) Develop and enforce land use codes for agriculture and animal husbandry
   b) Strengthen institutional capacity to support rangeland management; develop community rangelands

vii) Establish and maintain a network of well-managed protected area in the lake Victoria basin
   a) Establish a functioning regional protected area-working group for protection and management functions, financial arrangements, recommending new protected area and addressing management of protected area located along international borders
   b) Obtain government endorsement for the recommended protected areas
   c) Evaluate the priority targets for protection in each protected area and how these fit into regional priorities
   d) Review and propose revisions for national legislation on protected area to permit environmentally friendly use of the protected areas

e) Allocate a zone within protected areas or adjacent to them for eco tourism activities
f) Provide training in national protected area management of eco tourism
g) Reduce poaching in protected areas by ensuring that legislation regulation hunting are strengthened and enforced
h) Increase stakeholder participation, including community ownership, of protected areas
i) Establish regional and national capacities to monitor, examine causes, and map (using GIS) geographic locations of protected areas, including protection objectives. Broadly disseminate the results to rural inhabitants

x) Reduce land degradation due to mining, stone quaring, brick making
a) Evaluate national legislation addressing mining and use of non-living resources
b) Create regional working group on land degradation due to mining, and recommend specific common regional improvements to policy and legislation
c) Implement recommendations of regional working group in national laws and regulations

xi) Develop land use plans
xii) Develop innovative monitoring and evaluation system

10.9. Forest Sector

i) Reduce rate of forest destruction
a) Identify main contributors to deforestation, including public and private sector, as well as legal and regulatory failures
b) Identify alternative sources for products historically produced from forests and link with appropriate incentives and disincentives
c) Identify means to increase efficiency and reduce waste in use of forest products, through demonstration projects
d) Strengthen legislation to reduce rate of deforestation based on economic incentive and disincentives
e) Identify bio-fuels to replace wood fuel
f) Strengthen reforestation program and begin their implementation in affected areas, at village, community, and regional levels
g) Establish regional and national capacities to monitor, examine causes and map (using GIS) rate and geographic locations of deforestation and reforestation. Broadly disseminate the results to rural inhabitants

ii) Reduce rate of loss of land to desertification
a) Increase awareness of local populations of the desertification process, perhaps working through existing mechanisms
b) Improve legal basis in each country for combating desertification, including: criteria to define land degradation; amended law on forestry, water resources and land, and strengthened legal mechanisms such as EIA and planning procedures
c) Develop a desertification monitoring system and widely disseminate result
d) Demonstrate ways to reverse desertification
a) Perform demonstration projects of ways to avoid adverse environmental impacts of mining

iii) Develop culturally-adopted improvements to land tenure system/property rights in the region

a) Perform investigation of the policy, legal, and cultural basis for land tenure policies in the lake basin
b) Develop more effective methods of land tenure to reduce tendency for migration to fresh lands, and to encourage "investment" in lands (e.g. efficient irrigation improved crop methods)
c) Implement environmentally sustainable land tenure system in the region, perhaps as " special planning zone"

iv) Reduce catchments erosion rates by 25% by 2015

v) Fill gap in knowledge
a) Conduct assessment of effects of farming on coastal erosion on the catchments
b) Develop catchments erosion management plan through a participatory process

Promote environmental and community-based tourism
a) Strengthen legal basis for protection of coastline
b) Review harmonize and strengthen relevant local and national policies and legislation regarding coastal zone and river basin management

10.10. Agricultural Sector

i) Develop programs to reduce impact of agriculture and animal husbandry
a) Riparian countries agree to a list of banned agrochemicals and develop a program to destroy stored banned product
b) Riparian countries agree on limits to the application of agrochemicals and develop strategies to encourage the sustainable use of organic manure fertilizer
c) Riparian countries agree on regional controls on bushfires for agriculture, pasturage, and hunting, and enforce the controls
d) Conduct training courses at farmer and industry level to apply the most appropriate and new findings in their practice by 2015
e) Strengthen and enforce regulations on the disposal of animal waste
f) Develop more efficient ways to use existing land, increasing yields through better land management, crop rotation, or crop selection
g) Develop basin-wide corridors for seasonal migration of livestock through adjacent countries, based on historical common use zones
h) Develop community-base agricultural/ animal husbandry networks for transfer of technology and best practice
i) Establish regional and national capacities to monitor, examine causes, and map (using GIS) geographic locations of agriculture and animals husbandry, including protection objectives. Broadly disseminate the results to rural inhabitants

ii) Develop programs for;
a) improved marketing chains
b) Improved value addition of agricultural products targeting export markets
c) Guaranteed minimum returns
d) Improved access to credit

iii) Enhance capacity for irrigated agriculture (e.g. Rehabilitate irrigation schemes)

iv) Encourage diversification of enterprises and crop uses

iv) Enhance research and extension services

10.11. Mining Sector

ii) Evaluate national legislation addressing mining and use of non-living resources
iii) Organize artisanal miners into viable production and marketing units
iv) Improve value addition of mineral resources
v) Enhance access to credit
vi) Develop innovative monitoring and evaluation system

10.12. Energy Resources

i) Invest in alternative energy sources
ii) Promotion of a regional energy market

10.13. Cross-cutting issues

i) Develop innovative monitoring and evaluation systems
ii) Develop sustainable funding mechanisms
iii) Pursue ecosystem management of Lake Victoria basin
iv) Control and management of HIV/AIDS

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ANNEX
A1. Avian species composition in Kenyan wetlands

Common names	Species	Status
Reed cormorant	*Pharacrocorax africanus*	+
Long tailed cormorant	*Pharacrocorax africanus*	+
White breasted cormorant	*Pharacrocorax carbo*	+
African Darter	*Anhinga melanogaster*	+
Little egret	*Egretta garzetta*	+
Great-white egret	*Egretta alba*	+
Yellow-billed egret	*Egretta intermedia*	+
Cattle egret	*Bubulcus ibis*	+
Squacco heron	*Ardea ralloides*	+
Goliath heron	*Ardea goliath*	+
Grey heron	*Ardea cinerea*	+
Black-headed heron	*Ardea melanocephala*	+
White stock	*Ciconia ciconia*	-
Abdim's Stork	*Ciconia abdimii*	+
Marabou	*Leptoptilos crumineferus*	-
Hamerkop	*Scopus umbretta*	+
Yellow-billed stork	*Mycteria ibis*	+
African open-billed stork	*Anastomus lamelligerus*	+
Saddle-billed stork	*Ephippiorhynchus senegalensis*	-
Hadada ibis	*Bostrychia hagedash*	+
Sacred ibis	*Threskiornis aethiopica*	+
Glossy ibis	*Plegadis falcinellus*	+
African spoonbill	*Platalea alba*	+
Egyptian goose	*Alopochen aegypticus*	+
Spur-winged goose	*Plectropterus gambensis*	+
Fulvous tailed whistling ducks	*Dendrocygna bicolour*	+
White-faced whistling duck	*Dendocyna viduata*	+
African fish-eagle	*Haliaeetus vocifer*	+
African marsh-harrier	*Circus ranivorus*	+
Black kite	*Milvus migrans*	+
Augur buzzard	*Buteo auguralis*	-
Black-crake	*Amaurornis flavirostris*	+
Common moorhen	*Gallinula chloropus*	+
Purple gallinule	*Porphyrio porphyrio*	+
Crested crane		+
Grey-crowned crane	*Balearica regulorum*	-
African Jacana	*Actophilornis Africana*	+
Common stilt	*Himantopus himantopus*	+
Common pratincole	*Glareola pratincola*	+
Ringed plover	*Charadrius hiaticula*	+
African wattled lapwing	*Vanellus senegallus*	-
Long-toed lapwing	*Vanellus crassirostris*	-
Spur-winged lapwing	*Vanellus spinosus*	-
Crowned plover	*Vanellus coronatus*	-
Little stint	*Caladris minuta*	+
Pectoral sandpiper	*Caladris melanotos*	-
Ruff	*Philomachus pugnax*	-
Redshank	*Tringa tetanus*	
Green shank	*Tringa nebularia*	+
Wood sandpiper	*Tringa glareola*	+
Common sandpiper	*Actitis hypoleucos*	+
Grey-headed gull	*Larus ridibundus*	+
Herring gull	*Larus argentatus*	+

Common names	Species	Status
Hemprich gull	*Gelochelidon nilotica*	+
White winged black terns	*Chlidonias leucopterus*	+
Little tern	*Sterna albifrons*	+
Gull-billed tern	*Gelochelidon nilotica*	+
Namaqua dove	*Oena capensis*	+
African mourning dove	*Streptopelia decipiens*	+
Fischer's lovebird	*Agopornis fischeri*	-
Speckled mousebird	*Colius striatus*	+
Grey-headed kingfisher	*Halcyon leucocephala*	-
Malachite kingfisher	*Corythornis cristata*	+
Pied kingfisher	*Ceryle rudis*	+
Larks		-
Common bulbul	*Pycnonotus barbatus*	+
Cistocals		+
Sunbirds		+
Long-tailed fiscal	*Lanius cabanisi*	+
White-helmet shrike	*Prionops plumata*	+
Pied crow	*Corvus splendens*	+
African drongo	*Dicrurus adsimilis*	+
Superb starling	*Spreo superbus*	-
Wattled starling	*Creatophora cinerea*	-
Ashy starling	*Cosmopsarus unicolor*	-
House sparrow	*Passer domesticus*	+
Chestnut sparrow	*Passer eminibey*	-
Black-headed weaver	*Ploceus cucullatus*	+
Viellot's black weaver	*Ploceus nigerrimus*	+
Yellow-backed weaver	*Ploceus melanocephalus*	+
Golden backed weaver	*Ploceus jacksonii*	+
Northern masked weaver	*Ploceus taeniopterus*	-
Little weaver	*Ploceus luteolus*	-
Cardinal quelea	*Quelea cardinalis*	-
Red-billed quelea	*Quelea quelea*	-
Zanzibar red bishop	*Ueplectes nigroventris*	-
Black-winged red bishop	*Euplectes afer*	-
Blue cheeked cordon-bleu	*Uraeginthis angolensis*	-
Common waxbill	*Estrida astrid*	-
Pin-tailed whyadah	*Vidua macrroura*	+
Bronze Mannikin	*Lonchura fringilloides*	-

(+ indicates present, - indicates absent in Lake Victoria basin. Adapted from P. Kansoma eds).

A2. Terms of Reference

The Transboundary Diagnostic Analysis (TDA) will focus on priority environmental issues that are transboundary in nature. The consultant shall;

i) Review information available from LVEMP and other sources to establish nature of the problems, extent and geographical location of the key transboundary issues;

ii) Conduct interviews and field visit to identify priority environmental and socio-economic issue/problems that are transboundary nature and which must be addressed for the sustainable management in the lake basin and relate the problems/issues to the root causes;

iii) Identify the information/knowledge gaps, which need to be filled in transboundary problems, their causes, impacts, socio-economic consequences, the perceived solutions, and priorities of transboundary nature;

iv) Review and examine the nature and causes of the specific transboundary problems identified as contributors to ecosystem degradation and change in the Lake Victoria basin;

v) Prioritize the transboundary issues and identify activities and/or solutions to the issues.

vi) Assess extent to which the issue have been addressed over time and establish the gaps;

vii) Conduct a comprehensive analysis of transboundary issues from the National perspective and propose methods of addressing the problems and to ensure maintenance of ecosystem health and management of pollution;

viii) In addressing the above tasks, liaise with the Regional Consultant and other National Consultants in the other riparian States on crossing issues;

ix) Coordinate and facilitate meetings and National Workshops with stakeholders to gather more information and present reports.

x) Prepare a TDA report which addresses environmental and socio-economic problems, their causes and effects, and proposes possible solutions.

A3. Contributions by Sub-constructed Consultants

Name	Address	Contribution
Dr. Diana M.S. Karanja	Kenya Medical Research Institute	Human Health Issues in Lake Victoria basin
Dr. Albert Getabu	Kenya Marine and Fisheries Research Institute	Fisheries
Prof. Ogoche Jondiko	Maseno University	Natural resource issues
Mr. John Okungu	Ministry of Water and Irrigation	Water quality issues

ANNEX A4. Lists of Lake Victoria basin stakeholders consulted

a) Participants in National Stakeholders Consultative Workshops for TDA

	NAME	DESIGNATION	ORGANISATION	EMAIL	TEL. NO.
1	Abdul Mwasserah	PC – Western	Western Province	mawabdul2001@yahoo.com	0722776150
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5	Ann Ngetich	Chairperson	Chemaluk W. Group		0721148614
6	Anna N. Katuse	SIA	MENR	akatuse@yahoo.com	0734872797
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19	David K. Tanui	Forest Officer	KVDA	kvda@yahoo.com	0722446084
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21	Dorcas Wodera	AD/HRD	MENR	duwodera@yahoo.co.uk	0722604688
22	Dr. Enock Wakwabi	Deputy Director	KEMFRI	enockwakwabi@yahoo.com	0733837974
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84	Prof Henry Bwisa	Chairman	KIA	bwihem@yahoo.com	0722858507
85	Prof. George Khroda	PS	MENR		
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91	Rose Mugidde	P.C. – LVEMP	EAC- Tanzania		
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102	Zephaniah Nyakora	R.P	LBDA	nyahora62@yahoo.com	0733437737

b) Institutional stakeholders interviewed at their work stations

	Name	Position	Station/District
103.	Dr. Stephen Mbithi	Executive Secretary, AFIPEK	AFIPEK, Nairobi
104.	Mr. John Owino	Project Officer, IUCN	IUCN, Nairobi
105.	Mr. Erastus Orwa	Executive Officer, ECOVIC	ECOVIC, Mwanza
106.	Mr. Ngeno	Monitoring and Evaluation Officer, Department of Livestock	Department of Livestock Development, Nyanza Province
107.	Dr. Florence Odero	Provincial Director of Livestock Devt.	
108.	Dr. J.W. Jalango, Provincial	Director of Veterinary Services	
109.	Mr. Mark M. Shiakamiri	Administrative Manager	KEFFRI, Maseno
110.	Dr. James Kamere Ndufa	Senior Research Officer,	
111.	Prof. Tom Ogada	Director	KIRDI
112.	Dr. Charles Moturi	Deputy Director	KIRDI
113.	Catherine Gitobu		
114.	Mohammed Badaza		NBI – Kakamega (Sio-Malaba-Malakisi River basin)
115.	Daniel M. Muikia		
116.	Dr. Ndaiyia	Head, Analytical Chemistry	KEPHIS
117.	Mr. Njuguna	Analytical Chemist	

c) Primary stakeholders [farmers, fishers, miners, foresters, traders etc.] interviewed in their districts during field visits

Bondo District	
118.	Joanes Seda
119.	Mark Orwa
120.	Missible Ogutu
121.	Daniel Olulo
122.	Peter Ajulu
123.	Willis Atieno
124.	David Olulo
125.	Josphat Oswaga
126.	Mark Odhiambo
127.	Patricia Akoth
128.	Cathorina Amollo
129.	Doris Ogigo
130.	Monica Adede
131.	Esther Awour
132.	Rosemary Agutu
133.	Jane Kwaka
134.	Phoebe Jamua
135.	Joan Obonyo
136.	John Ochieng Obune
137.	Stephen Odipo
138.	Tom Ochieng
139.	Zephaniah Otieno
140.	Churchill Ojuaka
141.	Patrick Omondi
142.	Michael Odour
143.	Gilbert Okello
144.	Samson Onyango
145.	David Okollo
146.	Daniel Owino
147.	Richard Wanga
148.	James Okoth
149.	Otieno Wanga
150.	William Omondi
151.	Lucas Dulo
152.	Collins Otieno
153.	Tobias Agenyi
154.	James Okwama
155.	John Onyango
156.	Joseph Arombo
157.	Zedekia Oduma
158.	Joseph Okwany
159.	Richard Okoth
160.	Rosemary Atieno
161.	Jane Adhiambo
162.	Florence Obiero
163.	Mary Odeny
164.	Leonida Akinyi
165.	Susan Atieno
166.	Jane Okoth
167.	John Adilo
168.	Mariko Ochieng
169.	Joseph Odeyo
170.	Maurice Oulo
171.	Jacob Okombo
172.	Paul Onyango
173.	Alphonse Odongo
174.	Sella Atieno
175.	Pamela Oyugi
176.	Thomas Oduor
177.	Maurice Ochieng Auko
178.	Zipros Lupe
179.	Elizabeth Odipo
180.	Jenipher Ogeto
181.	Pamela Danga
182.	Samson Otieno Nyaringe
183.	George Sadia

Kisumu District	
184.	Silyvester Okonyo
185.	Rehema Ogweno
186.	Eunice Odoyo
187.	Jane Juma
188.	Monica Akoth
189.	Elizabeth Oguma
190.	Musa Ogembo
191.	Helida Aluoch
192.	Roselyne Wagudi
193.	Pamela Owero
194.	John Ogonda
195.	Charles Otieno
196.	Collins Odhiambo
197.	Steve Omondi
198.	Joseph Onyango

199.	Kennedy Otieno
200.	Benjamin Nyombala
201.	Solomon Owino
202.	Lucas Mbuya
203.	Steve Otieno
204.	Kennedy Omondi
205.	Moses Owino
206.	Collins Peter
207.	James Adera
208.	David Odhiambo
209.	Abraham Odida
210.	Kenneth Ocholla
211.	Erick Otieno Agolla
212.	Claris Atieno
213.	Salome Anyango
214.	Margret Anyango
215.	Susan Arunga
216.	Loice Oluwe
217.	Magdaline Atieno
218.	Pamella Atieno Odera
219.	Margret Aluoch
220.	Monica A. Arony
221.	Margret A. Juma
222.	Wilfrida Okinda
223.	Consolata Juma Ondiek
224.	Willis Onyango Obonyo
225.	Joshua Odida
226.	Fred Gumbe Osio
227.	Habil Onesmus Kinda
228.	Bernad Omonda
229.	Erick Ongola Atieno
230.	Edwin Omondi
231.	Daniel Owino Guta
232.	Daniel Owino
233.	Richard Otieno Ogolla
234.	John Odera
235.	Hesbon Anditi

Suba District	
236.	Peter Mwoso
237.	Joseph Onyango
238.	Awuor Odindo
239.	Macheal Otieno
240.	Ely Ouma
241.	Peter Okong'o
242.	George otieno
243.	James Mangla
244.	Jagero Okeyo
245.	Ely Otieno
246.	George Odhiambo
247.	David Odhiambo
248.	Joseph Otieno
249.	Simon Onyonyi
250.	Samson otieno
251.	Lucas Omega
252.	Kenneth Ouko Nyamodo
253.	Lucy Boaz
254.	Rose Atieno
255.	Doris Onyango
256.	Ludphine Odoyo
257.	Monica Anyango
258.	Rebecca Atieno
259.	George Amenya
260.	George Ager

261.	Lawi Obonyo
262.	Erick Okumu
263.	Mike Odhiambo
264.	Charles Ong'wen Ariwo
265.	Mike Onyango
266.	Joshua Ochieng
267.	Samson Ochieng
268.	Charlers Okunya
269.	Moses Otieno
270.	Alfred Kola
271.	Victor Anditi
272.	Daniel Odhiambo
273.	Samwel Onyango

Homa-bay District	
274.	Carolyne Akoth
275.	Irene Akeyo
276.	Carolyne Anyango
277.	Mary Anyango
278.	Mary Adhiambo
279.	Askah Akinyi
280.	Alga Apondi
281.	Caroyne Atieno
282.	Racheal Anyango
283.	Judith Akinyi
284.	John Okoth
285.	Mike Otieno
286.	George Onyango
287.	Charles Otieno
288.	George Owaka
289.	Benard Juma
290.	Peter Ochieng
291.	Benard Otieno
292.	John Otiende Boi
293.	Carolyne Auma Odongo
294.	Daniel Olungo
295.	Mike Okuta
296.	David Olunga
297.	Isaya Juma
298.	John Omondi
299.	Joseph Otieno

Rachuonyo District	
300.	Johnson oduor
301.	Gordon Juma
302.	George Otieno
303.	George Olum
304.	Samwel Okoth
305.	Johnson oduor
306.	Gordon Juma
307.	George Otieno
308.	George Olum
309.	Samwel Okoth

Busia District	
310.	Ojangi O.Sibiya
311.	Felista Awino
312.	Victorina Okondo
313.	Lilian Anyango Achieng
314.	Pamela Atieno Omondi
315.	Christian Wanyama
316.	Catherine Musolo
317.	Philis Akoth Buluma

A5. Work plan for the TDA

Period	Activities	Stakeholder/Site/Place
	Planning	
17.10.05	Meeting with LVEMP II /MENR Coordinators	Kisumu
18th .10.05	Prepare of work plan and Stake holders list for MENR/LVEMP II	KMFRI offices
19th-23rd.10.05	Desk literature search and assembly	Kisumu-KMRI libray, District Documentation center kisumu, PCs offices –Nyanza, LVEMP Secretariat
	Literature on Atmospheric deposition	Moi University,
24-25th .10.05	Visit Sio-Malaba –Malakisi	Nile Basin Initiative offices-Kakamega, Sio river/Port Victoria
26-28th.10.05	Visit and assessment of capacities at national and local Institutions	LVEMP Secretariat, Fisheries Management, Fisheries Research (KMFRI),
		Catchments A forestation (MENR), Water Quality (MoW&I),
		Capacity Building (Moi University), Ministry of Agriculture
		MENR-NRB, University of Nairobi, Fisheries Department HQs, UNEP HQs
29th-31st.10.05	Site visits, Transboundary and Mara river basin	Muhuru Bay, Trans Mara County Council/ Game warden -Masai Mara game reserve,
1-5rd.11.05	Compilation and analysis (collation) of baseline survey data.	KMFRI-offices
7th February 06	Hand over Draft Inception Report to Technical reviewers	Nairobi
18th March 2006	Hand over Inception Report with comments from Technical reviewers	Nairobi
24th March.06	Stakeholders Inception W/shop	Nairobi
27th March 2006	Handover Inception Report	Nairobi
27thnh March-17the April 2006	Preparation of Mid-Term Report	KMFRI-
18th April 2006	Hand over Mid-Term Report	Nairobi
26-28th April 2006	National Stakeholders workshop	Kisumu
May-June 2006	Further field visists;Visit stakeholder institutions	
21-23rd June 2006	National stakeholders workshop	Kisumu
June-August	Further field visists;Visit stakeholder institutions	
10-13th August 2006	Completion TDA Final Report	KMFRI
14th April 2006	Hand over TDA Final Report	Nairobi
22-23rd August 2006	National Stakeholders workshop	Kisumu