BASELINE FOR WETLANDS AND BIODIVERSITY OF NILE BASIN KENYA

Lower Sosiani River Basin, Kenya

THE NILE TRANSBOUNDARY ENVIRONMENTAL ACTION PROJECT

NILE BASIN INITATIVE

AUGUST 2009

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Foreword

The Nile Basin Initiative (NBI) is a partnership between riparian countries of the Nile; namely Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. The NBI's shared vision is to "achieve sustainable socioeconomic development through the equitable utilization of, and benefit from the common Nile Basin water resources". To translate this shared vision into action, there are two complimentary programs: the Shared Vision Program (SVP) which creates a basin wide enabling environment for sustainable development; and the Subsidiary Action Programs (SAPs) engaged in concrete activities for long term sustainable development, economic growth and regional integration of the Nile Basin countries.

The Nile Transboundary Environmental Action Project (NTEAP), one of the projects under the Nile Basin Initiative's (NBI) Shared Vision Program, was mandated to provide a strategic environmental framework for the management of the Trans boundary waters and environmental challenges in the Nile River Basin. One of the ways NTEAP met this objective was to document national baselines on the status of the wetlands and biodiversity in each Nile Basin Country. The documentation of the baselines was an opportunity to bring together experts from more than one discipline in compiling the available information and present it in a way that would be enriched to reverse the effects of the degradation of wetlands and their biodiversity.

This baseline has been prepared with the contributions from various experts as identified in Kenya. It is interesting to note the various fields of expertise on Wetlands and Biodiversity available in Kenya, with what is known but most importantly, the levels of information gaps that exist which ignite a potential for research to address them. Many of the actions prioritized herein can easily be dealt with through strengthening the networks, collaboration and development of joint action programs and periodic sharing of researched information using a well coordinated approach that would ensure sharing and use of the information.

This publication provides useful information on wetlands, ecosystems and biodiversity which is not only useful for management but can also be important for education, awareness and training purposes. Capacity building mentioned in each of the chapters is necessary for sustainability. The Nile Basin Initiative shall continue its efforts to coordinate information sharing at a regional level especially in linking up the regional scientists in sharing information.

We hope that this publication will be useful to managers, communities, educators, research institutions, NGOs, regional agencies and all stakeholders wishing to sustainably conserve and manage wetlands and their biodiversity.

Gedion Asfaw
Regional Project Manager
Nile Transboundary Environmental Action Project

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This baseline report is a result of the endless efforts of the networks of experts in the different sectors and sub-sectors that include the Wetlands, Micro-organisms, Plants, Invertebrates, Fishes, Amphibians and reptiles, Birds, Mammals, Socio-economic status and People of Nile Basin Kenya and their Institutional and Legal Considerations and Capacity Building. The preparation of this important book would not have been possible without the support, hard work and endless efforts of a large number of individuals and institutions. Particularly thanks go to the coordination efforts led by the NTEAP Wetlands and Biodiversity Specialist and Team Leader Dr. Henry Busulwa and the National Project Coordinator, Kenya, Ms. Lily Kisaka.

Gratitude is owed to institutions for both generating new knowledge over the years and also for being the custodians of extremely useful information. These institutions have trained veritable researchers and scientists over a period of time who have contributed immensely to the existing knowledge base. These institutions include: Ministry of Environment and Natural Resources, Ministry of Agriculture, Ministry of Water and Irrigation, Ministry of Fisheries Development, National Environment Management Authority, National Museums of Kenya, Moi University, University of Nairobi, Maseno University, Egerton University, Kenya Wildlife Services, Kenya Forest Service, Kenya Agricultural Research Institute, Kenya Forestry Research Institute, Kenya Marine and Fisheries Research Institute.

Sincere thanks to all the people who have contributed to and worked on information as presented in this book and the researchers that have contributed to the region's knowledge basin during the last forty years and beyond.

Ms. Rose Sirali Antipa is most thanked for editing the book and providing the key messages and highlights throughout the book.

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Foreword 3
ACKNOWLEDGEMENTS 4
LIST OF ACRONYMS 8
EXECUTIVE SUMMARY 10
CHAPTER 1: THE NILE BASIN KENYA 15
1.0 Introduction 15
1.1 Background 15
1.2 Lake Victoria 15
1.2.1 Flora and Fauna 16
1.2.2 Rivers and associated Wetlands in Kenya 16
1.2.3 Satellite Lakes 22
1.2.4 Dams 22
1.3 Objective of this Book 22
References 22
CHAPTER 2: THE PEOPLE OF NILE BASIN KENYA 23
2.1 Introduction 23
2.2 Ethnic composition 23
2.3 Culture 24
2.4 Sociology, demography and culture 24
2.4.1 Ethnic groups and traditional socio-economic setting 24
2.4.2 Highland Nilotes - Kalenjins of Rift Valley 25
2.5 Olare Onyokie-Kipkaren sub-catchments on Nandi Hills 26
2.5.1 Kipsigis 26
2.5.2 Nandi 27
2.6 Moiben Sub-catchment on Cherengani Hills 28
2.6.1 Marakwet 28
Development activities in Moiben River Basin today. 28
2.6.2 Sengwer 28
2.6.3 Keiyo 29
2.7 Kuywa sub-catchment on Mt. Elgon 29
2.7.1 Sabaot 29
2.7.2 Dorobo – hunters and gatherers 30
2.7.3 Luyia 31
2.8 Cultural factors affecting catchment management 34
2.9 Migrants, settlers and business people 34
2.10 Gender, marginalized and vulnerable groups 35
2.10.1 Vulnerable groups – HIV/AIDS 35
2.10.2 General 35
2.10.3 Women as a vulnerable group 36
2.10.4 Children as a vulnerable group 37
2.11 Gender relations and roles 37
2.12 Marginalized groups 37
2.13 Indigenous Knowledge 38
2.14 Natural resources 40
2.15 Knowledge gaps 40
2.16 Recommendations 41
References 41
CHAPTER 3: THE WETLANDS 43
3.1 Introduction 43
3.2 Definition of Wetlands 43
3.3 Wetlands of the Nile Basin Kenya 45

3.4 Wetland services, functions and values 46
3.5 Present situation and trends 49
References 50
Wetland Experts in Kenya 52
CHAPTER 4: MICRO-ORGANISMS 52
4.1 Introduction 52
4.2 Wetland Bacteria 53
4.2.1 Nitrifying bacteria 53
4.2.2 Denitrifying bacteria 55
Figure 4.1 Denitrification processes in wetlands 55
4.2.3 Nitrogen fixing bacteria 55
4.2.4 Sulphur/Iron bacteria 56
4.2.5 Methanogens/Archaebacteria 56
4.3 Fungi 57
4.4 Wetland algae 57
4.5 Researches on the use of wetland micro-organisms and wetland environment 58
4.5.1 Development of constructed wetlands 58
4.5.2 Removal of metals by sulphate-reducing bacteria (SRB) from acid mines 58
4.6 Knowledge gaps 58
4.7 Recommendations 59
References 59
CHAPTER 5: PLANTS 60
5.1 Introduction 60
5.2 Wetland plants 60
5.3 Restoration of degraded wetlands vegetation 63
5.4 Knowledge gaps 64
5.5 Recommendations 64
References 65
Wetland Plants Experts in Kenya 65
CHAPTER 6: INVERTEBRATES 66
6.1 Introduction 66
6.2 Previous and ongoing research in Lake Victoria Basin 67
6.3 Knowledge gaps 68
6.4 Recommendations 68
References 68
Aquatic Invertebrates Experts in Kenya 69
CHAPTER 7: FISHES 69
7.1 Introduction 69
7.2 Fish species composition and distribution in the Lake Victoria Basin 70
7.2.1 Introduced fish species 71
7.3 Fisheries of Lake Victoria, Kenya 71
7.4 Satelite lakes, dams and swamps 72
7.5 Rivers 75
7.6 Current research and conservation activities 75
7.7 Knowledge gaps 76
7.8 What needs to be done 76
7.9 Recommendations 77
References 77
Fish Biology Experts 79

LIST OF FIGURES

Figure 1.1 Lake Victoria North Catchment area 16
Figure 2.1 Lake Victoria and Catchment 18
Figure 2.2 Population of Olare-Onyokie Kipkaren sub-catchment of Nandi Hills 21
Figure 3.1 Wetland resources in Lake Victoria catchment, Kenya 39
Figure 4.1 Denitrification processes in wetlands 47
Figure 4.2 The formation of ammonium from N by nitrogen fixing bacteria 48
Figure 7.2 Annual catches from the Kenyan waters of Lake Victoria (1968-2003). 65
Figure 9.1 Major catchment region of the Nile Basin Kenya. 79
Figure 9.2 Trends in total waterbirds in four sites of Lake Victoria wetlands 84
Figure 10.1 Distribution of De Braza monkey *Cercopithecus niglectus* 90
Figure 11.1 Density growth around Lake Victoria 93

LIST OF TABLES

Table 2.1 Population and poverty of Rift Valley and Western Provinces Districts 20
Table 2.2 Population distribution in Luyia and Sabaot settlement districts 28
Table 2.3 HIV prevalence among adults tested 30
Table 3.1 Characteristics of the world's wetlands 36
Table 3.2 Classification of wetlands in Lake Victoria Basin 40
Table 4.1 Classification of bacteria important in the wetlands 46
Table 7.1 Fish species and percentage occurrence in Lake Victoria, Kenya 63
Table 7.2 Checklist for fish species in rivers of Lake Victoria Basin, Kenya. 66
Table 7.3 Fish species of the satellite lakes and dams 67
Table 9.1 Forest areas of Lake Victoria Basin in Kenya 81
Table 9.2 Important Bird Area sites in the Nile Basin 82
Table 9.3 Sites around Lake Victoria where waterfowl monitoring has been done 83
Table 9.4 Total number of waterbird and species recorded in Dunga Swamp 83

LIST OF PLATES

Plate 2.1 Development activities in Moiben River Basin today 23
Plate 2.2 Challenges in Kuywa River Basin. 25
Plate 2.3 A woman selling fish in Kisumu Town 32
Plate 5.1 Water hyacinth, *Eichornia crassipes* mass on Lake Victoria. 53
Plate 5.2 Morphology and structure of water hyacinth, *Eichornia crassipes*. 53
Plate 5.3 Effects of water hyacinth on human activities on the Lake Victoria. 54
Plate 5.4 Water Hyacinth mechanical control method 54
Plate 5.5 Water Hyacinth biological control methods 55
Plate 10.1 Heterogenous swampy bushes preferred by *Tragelaphus spekei spekei*. 88
Plate 10.2 Human activities in current *Tragelaphus spekei spekei* habitat 89

LIST OF ACRONYMS

ADC	Agricultural Development Corporation
AFWC	African Waterfowl Census
AM	Arbuscular Mycorrhizal
BINU	Biodiversity Indicators for National use
CBO	Community Based Organizations
CBOL	Consortium for the Barcode of Life
CBOs,	Community Based Organizations
EANHS	East African Natural History Society
EC	Electrical Conductivity
EC	European Commision
EIA	Environmental Impact Assessment
EU	European Union
FAO	Food Agricultural Organization
FAO/CIFA	
FGM	Female Genital Mutilation
GEF	Global Environment Facility
GIS	Geographic Information System
GOK	Government of Kenya
HIV/AIDS	Human Immune Virus/Acquired Immune Deficiency Syndrome
IBAs	Important Bird Areas
ICRAF	World Agro-forestry Center
IEM	Integrated Ecosystems Management
ILEC	International Lakes Environment Committee in
IUCN	International Union for Conservation of Nature
IUCN/EARO	International Union for Conservation of Nature/East Africa Regional Office
IWC	International Waterfowl Census
IWRM	Integrated Water Resource Management
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KEMRI	Kenya Medical Research Institute
Km^2	Square Kilometer
KMD	Kenya Meteorological Department
KMFRI	Kenya Marine Fisheries Research Institute
KMFRI	Kenya Marine Fisheries Research Institute
KWS	Kenya Wildlife Services
KWS	Kenya Wildlife Service
LBDA	Land Basin Development Authority
LV	Lake Victoria
LVB	Lake Victoria Basin
LVDP	Lake Victoria Development Program
LVEMP	Lake Victoria Environmental Management Project
LVN WRMA	Lake Victoria North Water Resources Management Authority
LVSB	Lake Victoria Sunset Birders
NBI	Nile Basin Initiative
NEMA	National Environmental Management Authority
NGOs,	Non Governmental Organizations

NMK	National Museums of Kenya
NRM	Natural Resources Management
NTEAP	Nile Transboundary Environmental Action Project
NTU	Normalized Turbidity Units
OVC	Orphans and Vulnerable Children
PLWA	People Living with Aids
SRB	Sulphate-Reducing Bacteria
SVP	Shared Vision Program
SWB	Small Water Bodies
TDS	Total Dissolve Solids
UNEP	United Nations Environment Programme
UNESCO	United Nationas Environmental
US ACOE	US Army Corps of Engineers
UV	Ultra Violet
WI	Wetland International
WRM	Water Resources Management
WRMA	Water Resources Management Authority

EXECUTIVE SUMMARY

Wetlands found in Nile Basin Kenya are mosaic of habitats comprising, Lake Victoria, satellite lakes, rivers, dams and swamps. These wetlands support about 12 million people who extract freshwater, fish, medicinal plants and building materials. In addition, wetlands are important in terms of food production, hydrological stability, biodiversity conservation and ecological productivity. The Lake Victoria basin wetlands are undergoing significant changes in terms of quantity and quality of fisheries, plant community structure and perhaps genetic structure of resident organisms. However, information is lacking on the biological integrity of the Lake. Furthermore, there are no established bio-indicators and a suitable monitoring program. The capacity of national institutions to assess and monitor wetland functions and biodiversity is limited by lack of adequate resources, including funds, capital equipment and facilities. Socio-economic research on wetland resources is limited both in scope and depth, its impact on degenerating wetlands, notwithstanding. This report is an attempt to document the knowledge on wetland resources of the Nile Basin Kenya.

This book is organized into twelve chapters. Chapter one is a general introduction providing a compilation of the information about the Nile Basin Kenya including its geographical features, area and socio-economic status as well as the objective of the book. Chapter two describes the people of the Nile Basin Kenya, their ethnic composition, culture, traditions, and indigenous knowledge. The main ethnic communities living in the Lake Victoria Basin include Luhya, Luo, Kisii, Kuria, Maasai, Suba, Kalenjin and Teso. Incorporating indigenous knowledge into biodiversity conservation and development activities is believed to be an important mechanism for ensuring the most efficient and productive use of natural resources. However, indigenous knowledge systems and technologies are not adequately promoted and protected in most ethnic communities. There is need to promote indigenous knowledge which promote biodiversity conservation.

Chapter three gives the definition, limnology, wetland types, classification of wetlands, wetland services, functions and values. The driving forces of change in Nile Basin Kenya wetlands include: human population pressure, especially its increasing size; rapid growth rate and increasing urbanisation and migration from inland to the lakeshores. Socio-cultural factors, such as the traditions, lifestyles and informal resource-use rules of the local community have also influenced wetlands perception, use and management. Lack of adequate and appropriate knowledge about the functions and values of wetlands has hindered active management, including rehabilitation of degraded areas by the local community. Inappropriate policy and, weak legal and institutional frameworks have also contributed towards an unfavorable environment for wetland conservation and sustainable use.

Chapter four provides a review of the classification and characteristics of the microorganisms; research carried out so far on the use of wetland micro-organisms in Nile Basin in Kenya. The management options proposed are: there is need to bring wetland conversion processes under control by making informed decisions where and when not to convert as well as to improve on the already converted areas to protect vital functions, make use of wetland beneficial, sustainable and equitable. In addition the principle of wise use should be applied which states inter alia: “The Wise Use of wetlands is their sustainable utilization for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem”.

Chapter five reviews wetland plants found in Nile Basin Kenya. The plant species that have been identified by taxonomists, and are subsequently classified as emergent, floating leaved, free floating and submerged. The common emergent macrophytes in Yala Swamp and Nyando Delta are grasses such as *Echinochloa pyramidalis* which occupies seasonal wetlands, reeds *(Phragmites kirkii*), sedges *Cyperus papyrus* and *Typha domigensis* and tall water grasses such as *Paspalidium geminatun* and *Vossia cuspidate*. In recent years, rapid expansion of grasses and reeds from the landward side has significantly reduced the abundance of papyrus in Lake Victoria. Surface floating macrophytes are often looted to the bottom but their stems emerge out of the water surface. These include the duckweed *Lemnia spp*., water ferns *Azola spp.,* water cabbage *Pistia striotiotes* and water hyacinth, *Eichornia crassipes*. Water hyacinth is a major problem in Lake Victoria and is responsible for rendering the port inoperable for periods of time severely limiting fishing and blocking the municipal water intake. Mechanical control has mostly been unsuccessful since the weed grows faster than mechanical clearance can cope. The Kenya Agricultural Research Institute (KARI) introduced more than 200,000 weevils into the lake to feed on the weed which succeeded in reducing its spread. Submerged plants, which include *Najas* spp., *Potamogeton pectinatus* and *Ceratophyum demersum* are extremely sensitive to changes in water quality, especially due to chemical pollution and suspended sediment in bays and rivers flowing into Lake Victoria.

Chapter six gives a review of aquatic invertebrates, which constitute an important component of wetland biodiversity in Nile Basin Kenya. They play an integral role in the production dynamics of wetlands, aquatic food web, as bio-control agents, bio-indicators and as vectors. Unfortunately, the knowledge of aquatic invertebrate especially in Kenya and East Africa in general is scanty. Few studies carried out on important aquatic invertebrate have focused on economically important species, control of vectors, production ecology and biosystematics. This chapter provides previous and ongoing research in Lake Victoria basin, knowledge gaps, research required and recommendations. The chapter recommends: (1) Regional collaborations need to be strengthened to focus on research, monitoring and conservation; (2) there is need to develop an effective water-quality monitoring system involving key indicators and intolerant invertebrate species; (3) establish a detailed data base for all the information available on aquatic invertebrates of Nile River basin; (4 need to focus on aquatic invertebrate research themes that target specific groups and species of economic importance e.g. invasive alien species, vectors, and bio-agents, among others; (5) National and perhaps regional wetland policies should be concluded to secure the wetlands ecosystems and their valuable resources; (6) development of the culture of freely exchanging information, ideas and findings with stakeholders nationally and regionally.

Chapter seven contains a review of the fishes of Nile Basin Kenya which four decades ago were considered by many as one of the most speciose assemblages in the tropics. The fish species of the Nile basin Kenya were predominantly composed of haplochromine cichlids and over 38 non-cichlid species. Taken together, there were over 14 different fish families. The decline and the near disappearance of some fish species is attributable to multiple introduction of exotic species (*Lates niloticus*, *Oreochromis niloticus*, O. *leucostictus*, *Tilapia zillii* and *T. rendallii*) and several anthropogenic activities, including wrong fishing methods which together have impacted negatively on the system and negated any efforts towards sustainable exploitation and conservation of and fish species of the Nile Basin in Kenya. The chapter identifies the research gaps as: (1) Inadequate taxonomy of the fish species especially the haplochromines and cyprinids; (2) Inadequate population genetics studies e.g. hybridization between the native and introduced tilapiines species and the genetic status of the surviving indigenous fish species; (3) Lack of a centralized database for all the work done in the basin; (4) Poor state of data on the major rivers in the region; (5) Lack of Catch

Assessment data for satellite lakes; (6) Inadequate involvement of relevant stakeholders in the conservation of fishery resources especially on the small waterbodies and floodplains; (7) General lack of environmental awareness in the lake basin; (8) Potential impact of upstream migration of the piscivorous introduced Nile perch is unknown.

Chapter eight provides approximate number of currently known amphibian and reptile species in the Nile basin Kenya. Provided also are the species conservation gaps for future work. The existing gaps (e.g. sampling in majority of the unexplored areas) that can aid in conservation of species and their ecosystem are identified. Published species lists, unpublished data from taxonomic experts as well as the National Museums of Kenya (NMK) herpetology collection database were used. Despite Kenyan Nile basin diverse habitats and species diversity its amphibian and reptile fauna remain relatively unknown. There are about 39 amphibian and 100 reptile species with low endemism. The chapter recommends studies to establish species conservation status and biogeographical affinity in majority of the poorly explored areas in this region. Future conservation efforts should encourage all local activities that are likely to preserve village wetlands and forests in the Basin. Finally, all remaining indigenous forests and wetlands should be given highest conservation priority.

Chapter nine provides information on the areas where waterbird researches have been conducted. A total of 82 different wetland bird species have been recorded in the 14 different sites surveyed. The conservation of wetland birds and their habitats in Kenya require pragmatic and multi-disciplinary approach and political will for the formulation of effective policies and their sound enforcement at local and national level. The chapter recommends the following conservation interventions: (1) Waterbird surveys in all swamps around Lake Victoria and the islands in it as well as the riparian habitat of the permanent rivers which drain into the lake; (2) Detailed ecological studies targeting particular waterbird species in relation to their habitat requirements are required (e.g. Papyrus endemics, Papyrus dependent, etc.); (3) Strengthening the capacity of Community Based Organizations, local people and other institutions to get involved in the annual waterbird monitoring scheme currently being conducted in few sites around Lake Victoria, and to participate in general applied research on birds and their habitats.

Chapter ten gives a description of the various mammals found in wetlands in the Nile basin. The latter are *refugia* to many species during droughts besides daily water service. Unfortunately, wetlands are a target for many conservation unfriendly activities. Activities such agricultural expansions and settlement are primary causes of destruction and fragmentation of wetland habitats and inhabitant biodiversity. Fragmented inhabitant mammals populations then become either unviable and or prone to stochastic events. Conservation of wetlands is therefore critical for both socio-economic development, but also for biodiversity management. In the absence of knowledge on aquatic mammals in wetlands of Nile Basin, both conservation motivations and management decisions remain void. The chapter suggests that as a first step towards ensuring effective and sustainable management of wetlands in Nile Basin Kenya, is to emphasize the need to re-affirm the records for most species; mammal inventories and populations monitoring.

Chapter eleven reviews socio-economic status of wetlands of Nile Basin Kenya. Wetland products and services, such as transport and tourism, have potential to contribute towards poverty alleviation in rural areas. However, socio-economic studies that could illustrate the significance of wetlands to alleviation of rural poverty in Lake Victoria Basin are scarce. Substantial information however, exists on the socio-economic impacts of the declining fisheries and liberalisation of fish trade on people's livelihood and economic status. There is need for research to link socio-economic activities with the ecological requirements that are necessary to maintain and in fact enhance resources that people derive from wetlands. Since the main problem has been caused by population pressure on wetlands, efforts should be made address encroachment on wetlands, reduce deforestation, water pollution, air pollution, and waste management.

Chapter twelve concludes that the knowledge base of Nile Basin Kenya wetlands is relatively small and there is ample scope for more scientific and socio-economic research. Efforts to promote collaborative research between researchers and natural resource managers should be enhanced. A regional programme for research, monitoring and conservation (including sustainable use) of wetlands should be initiated by Nile riparian countries under the auspices of the Nile Basin Initiative.

Conclusion

Wetlands resources are under great pressure from growing human population in Lake Victoria Basin. These freshwater ecosystems are major recipients of land-based pollution and their ability to buffer the Lake is diminishing. Wetlands are also being encroached by human settlements; environmental impact assessment should guide on-going changes in land use.

The knowledge base of Nile Basin Kenya wetlands is relatively small and there is ample scope for more scientific and socio-economic research. Collaborative research between researchers and natural resource managers is important. A regional programme for research, monitoring and conservation (including sustainable use) of wetlands should be initiated by Nile riparian countries under the auspices of the Nile Basin Initiative. The fundamental socio-economic issues of rural poverty, poor public health, deteriorating water supply and sanitation systems, declining fisheries and non performing agricultural sector should be considered in any regional wetland research and conservation programme in the Nile Basin.

Moreover, the knowledge base of aquatic invertebrates of the Nile Basin Kenya is relatively small and there is ample scope for more scientific and socio-economic research. Threats to aquatic invertebrates are enormous and of anthropogenic nature that need concerted efforts in order to secure ecological integrity of our wetland ecosystems. Scientific information underpins any conservation efforts and therefore collaboration is essential between researchers and resource managers. There is need for coordinated regional research efforts to understand the dynamic, magnitude and impacts of eutrophication, invasive species, climate change etc. on aquatic invertebrates.

In order to forecast the future of Lake Victoria Basin, the biology of residual populations of indigenous species and the impact of anthropogenic activities within the Lake Basin must be integrated into a holistic management approach that goes far beyond fisheries. Resource managers must guide human activities in the lake Basin as an ecosystem in its entirety, including rivers, swamps, satellite lakes and dams, a sharp departure from current practice of treating the lake by and large as an isolated water body.

The importance of compliance and enforcement of environmental legislation and its subsidiary legislation should be emphasized. Continuous capacity building of the law enforcers and the communities will go a long way in ensuring that the Basin is conserved besides being used in a sustainable manner.

CHAPTER 1: THE NILE BASIN KENYA

Dr. W. O. Ojwang and Mr. J.E. Ojuok,
Kenya Marine and Fisheries Research Institute, Kisumu, Kenya

1.0 Introduction

1.1 Background

Wetlands in Kenya cover about 3-6% of the land surface and provide many ecological and socio-economic goods and services. These include water supply, food production, construction materials, and products for the cottage industry, tourism and recreation. The ecological services comprise flood control, water recharge and discharge, water filtration, nutrient storage and re-cycling and wildlife habitats. But despite their valuable functions, wetlands are continually being degraded and lost through conversion for agricultural uses, settlement and industrial development. Wetlands have suffered degradation induced by overexploitation, pollution, and catchment destruction. In addition, lack of awareness and appreciation of the values of wetlands has contributed to their loss and mismanagement.

The wetlands of Lake Victoria Basin (same as the Nile Kenya Catchment) constitute about 37% of the total surface area of wetlands (2,737,790 hectares) in the country. They are a mosaic of habitats comprising, Lake Victoria, satellite lakes, rivers, dams and swamps. In recent years, Lake Victoria Basin wetlands have undergone serious degradation. The cause of degradation include: excessive resource harvesting, overgrazing, conversion for agriculture and industrial development. Because of their ecological significance and importance to the livelihood of the local people, wetlands of Lake Victoria Basin need to be conserved and managed in a sustainable manner. The enormous socio-economic potential of wetlands in the Basin has not been fully exploited, primarily because of limited knowledge of wetland ecosystems and little appreciation of their role in combating poverty and supporting sustainable development. Over the past twenty years, attention has been increasingly focused on wetlands particularly with the coming into force of the Convention on Wetlands (Ramsar, 1971). Studies on wetland values and functions have revealed the need to take greater care with their management.

1.2 Lake Victoria

The main physical feature that identifies the East African countries is Lake Victoria and its catchment area. In terms of surface area, Lake Victoria is the second largest Lake in the world. It has a maximum recorded depth of 85 m and a mean depth of 40 m. It stretches 412 km from north to south between latitudes 0°30'N and 3°12'S, and 355 km from west to east between longitudes 31°37'W and 34°53'E. It contains numerous islands and has a highly indented shoreline which Welcomme (1972) estimated as 3,460 km long. However, published shoreline measurements are notably variable, since they depend absolutely upon the scale of map used for their determination and how far each indentation is measured.

The hydrology, water chemistry and biology of the Lake are dealt with in some detail in records from historical records. Trends of research in Lake Victoria Basin has aimed at determining the rate, variance and magnitude of critical control of the environment and its response to past and impending changes brought about by eutrophication, climate shifts and introduced species. Available information shows that the lake level rose by more than 2 m between 1961 and 1964 after a very long period of stability. The major rivers and their associated wetlands draining into Lake Victoria include the Kagera, Mara, Nzoia, Sio, Nzoia, Yala, Sodu-Miriu and Migori (Figure 1.1). All these rivers form extensive wetlands at their mouth that support a variety of a source of community livelihoods through direct extractive activities such as papyrus harvesting, medicinal plants, building material, grazing areas for livestock and water reservoirs for different uses among other economic activities.

1.2.1 Flora and Fauna

The phytoplankton is dominated by cyanophytes. Islands of *Cyperus papyrus*, with its typical associates, detach from the fringing swamps. The lake itself contains submerged species such as *Ceratophyllum demersum* and *Potamogeton spp*. around the margins, while waterlilies and *Pistia stratiotes* are found floating in quiet spots. Copepods and rotifers are abundant in the zooplankton. The fish fauna is essentially nilotic, but there are many endemics. According to Greenwood (1965) the lake contains 177 species of fish, of which 127 are cichlids. *Lates albertianus*, *Oreochromis leucostica*, *O. niloticus* and *Tilapia zillii* had been introduced into the Basin before 1962 and are now widely distributed. They certainly occur in all Kenyan waters. Certain species which are common in the lake are comparatively scarce in Winam Gulf, e.g., *Barbus altianalis*, *Labeo victorianus*, *Mormyrus kannume*, *Oreochromis esculentus* and *Schilbe mystus*. Many of the Equatorial East African animals occur in, or on the shores, of the Kenyan part of Lake Victoria, including water turtles, aquatic snakes, monitor lizards, crocodiles, a wealth of birds, rodents, otters and *Hippopotamus amphibius*.

1.2.2 Rivers and associated Wetlands in Kenya

These rivers rise in the highlands and flow into Lake Victoria, contributing a mean total volume of 7.29 billion m^3 water/year. The most important ones are, from north to south, the Sio, which forms the border with Uganda, and the Nzoia, Yala, Nyando, Sondu and Gucha/Migori Rivers. There are also many minor streams that drain into Lake Victoria. The Sio rises on the southern slopes of Mt. Elgon, while the Nzoia, a much larger river, rises high in the Cherangany Hills, but receives four major affluents from Mt. Elgon and another from the highlands along the central western part of the Rift Valley. Of the tributaries from Mt. Elgon, the Sosio rises over 3500 m above sea level, and the Ewaso Rongai, Koitobos and

Kuywa Rivers have sources near the 3000 m contour (Figure 1.1). The Yala River drains the central highlands west of the Rift Valley, as does the Nyando River, which has sources near Mt. Tinderet (0°06'S/35°21'E) 2640 m above sea level. The Sondu River rises on the dip (western) slopes of the Mau Escarpment, while the Gucha and Migori Rivers drain Mts. Kijaur (0°45'/34°58'E), 2166 m above sea level, and Moita (1°05'/34°44'E), 2037 m above sea level. All these rivers tend to flood in concert, having catchments in high rainfall zones with a prolonged wet season from April to October. Since in some places, the lacustrine plains are very flat, several of these rivers form extensive swamps on the lakeshore.

The Yala Swamp (0°07'N-0°01'S/33°58'-34°15'E) encompass the Nzoia Delta and all the lakeshore south to Ugowe Bay, and all the land east to Lake Kanyaboli. The swamp extend back up the Yala River in the south. In total, the swamp comprise 30 000 ha of wetland, including Lake Kanyaboli (1500 ha), and stretch 25 km from West-East and 15 km from North-South at the lakeshore. The swamp includes several minor lakes. Another swamp (0°11-0°19'S/34°47'-34°57'E) is situated at the mouth of the Nyando River at Nyakach Bay, extending back onto the Kano Plains, while another (0°18'-0°21'S/34°45'-34°48'E) occurs at the mouth of the Sondu River. The Nyando Swamp measures 15 km from West-East and some 6 km from North-South. Together the swamps on the Kano Plains occupy about 10 000 ha. To the south the Gucha (Kuja-Migori) Delta (0°54'-0°-58'S/34°08'-34°11'E) is also swampy, while small swamps occur immediately south of the town of Kisumu and at the mouth of the Mogusi River (Oluch) (0°28'S/34°31'E) close to Homa Bay.

Sio River, at the Kenya Uganda border

Water hydrologists taking measuresments at River Yala

Other 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 south to the equator. One such wetland, which includes both floodplain and permanent swamp, occurs on the Nzoia River (1°00'-1°09'N/34°57'-35°05'E) immediately north and east of Kitale. This wetland is 20 km long from North west-South east and 1-5 km wide and extend to about 6000 ha. A small permanent swamp, area 1000 ha is situated (0°52'N/35°13'E) north of the Little Nzoia River. Seasonal floods occur on the Kimandi

River, a tributary of the Yala River (0°12'-0°16'N/35°10'-35°16'E). This measures 12 km×6 km and covers 4800 ha.

River Kuywa

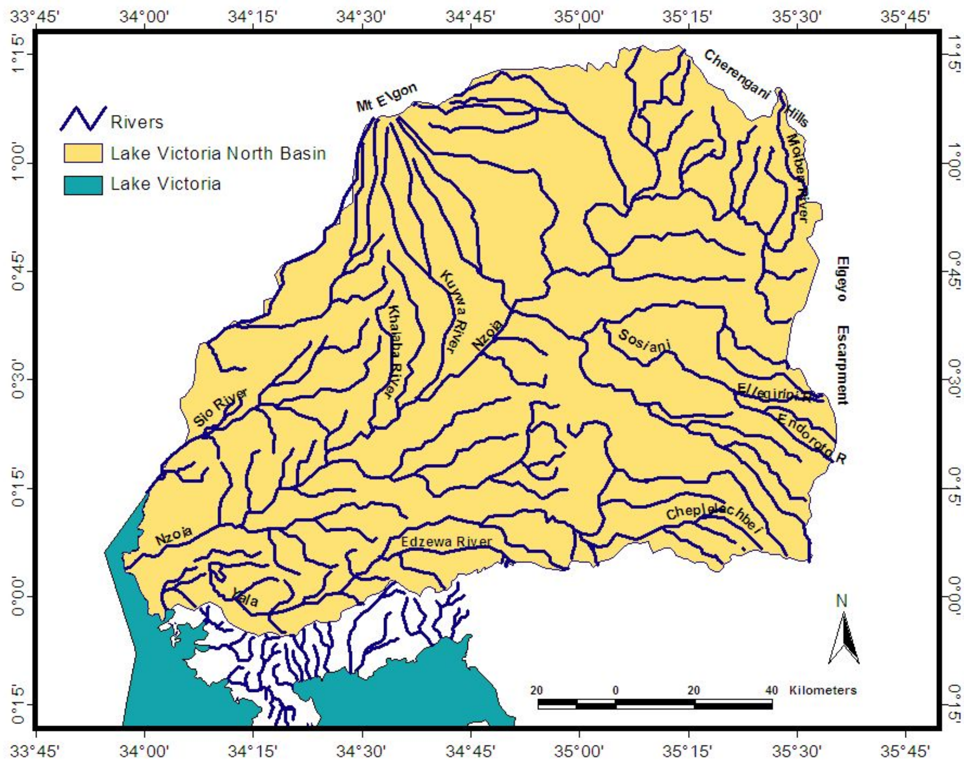

Figure 1.1 Lake Victoria North Catchment area (Source Water Resources Management Authority).

Districts in Kenyan Nile basin and their corresponding basins

	BASIN	**DISTRICT**
1	Nzoia	B/Mumias
1	Nzoia/Sio malaba	Bungoma
1	Nzoia	Busia
1	Nzoia	Kakamega
1	Nzoia	Lugari
1	Nzoia/Sio malaba	Mt Elgon
1	Nzoia/Sio malaba	Teso
1	Nzoia	T/Nzoia
1	Nzoia	U/Gishu
1	Nzoia	W/pokot
1	Nzoia	Marakwet
1	Nzoia/Nandi	Keiyo
1	Nzoia/Yala	Siaya
1	Yala/Nzoia	Vihiga
2	Nyando	Kericho
2	Nyando/Mau	Nakuru
2	Nyando/Yala/Nzoia	Nandi- North
2	Nyando/Yala/Nzoia	Nandi South
2	Nyando	Nyando
2	Sondu/Mara	Bomet
2	Sondu	Buret
3	Gucha migori	H/Bay
3	Gucha migori	Kisii
3	Gucha Migori	Kuria
3	Gucha Migori	Migori
3	Gucha/Migori/ Southern shoreline-	Nyamira
3	Gucha Migor/southern shoreline	Suba
3	Gucha/Migori/Mara	Transmara
3	Mara	Narok
4	Northern shoreline	Bondo
4	Northern shoreline	Kisumu
4	Southern shoreline	Gucha
4	Southern shoreline	Rachuonyo

Figure 1A: Map of the Nile Basin part of Kenya

1. Bondo	17. Kisumu
2. Siaya	18. Vihiga
3. Suba	19. Nakuru
4. Migori	20. Kakamega
5. Homabay	21. Butere/mumias
6. Kuria	22. Vihiga
7. Gucha	23. Teso
8. Kisii	24. Bungoma
9. Nyamira	25. Mt. Elgon
10. Transmara	26. Trans-Nzoia
11. Bomet	27. West Pokot
12. Narok	28. Marakwet
13. Kericho	29. Nandi
14. Buret	30. Keiyo
15. Rachuonyo	31. UasinGishu
16. Nyando	32. Malava/Lugari

Source: ICRAF

Figure 2A: hydrological map of the Nile basin

Main Rivers basins

Nzoia

Yala

Nyando

Sondu Miriu

Trans Mara

Source: Lake Basin Development Authority

1.2.3 Satellite Lakes

Lake Kanyaboli is one of the satellite lakes of Lake Victoria with a mean depth of 3 m and an area of 10.5 km^2. It has a catchment area of 175 km^2 and located approximately 14 km west of Siaya town. Lake Kanyaboli is a favourable nursery ground and refuge area for many fish and bird species. It has been nicknamed as a "living museum" for Lake Victoria fisheries because many fish species which have hitherto disappeared from Lake Victoria are still found in appreciable numbers in this lake. Lake Sare is about 5 km^2 and about 5 m deep at its centre. It is part of southern outlet of Yala River. It was a part of the Nyanza Gulf of Lake Victoria before a culvert was constructed across its present outlet into the gulf. It is surrounded by a fringe of papyrus swamp. Its only outlet is the culvert near the southern part of Got Agulu sand bar. Lake Namboyo is a very small but deep lake of between 10 m and 15 m depth with surface area of about 1 km^2. No other major use is known except as a water resource for local people and their livestock and fish for local consumption.

1.2.4 Dams

Several dams are found in the northern and southern portion of Lake Victoria Basin with characteristic fish fauna. These include: Stella, Olasi, Koketch, Uriri, Tinga, Migowa, Oyombe and Kosiga to the south and Tinga, Uranga, Ufinya, Kalenyjuok, Ugege, Mauna, Mwer and Ulanda to the north.

1.3 Objective of this Book

The aim of this book is to provide a baseline on the wetland and biodiversity in the Nile Basin Kenya, and raise interest for both research and conservation for sustainable utilization of wetlands. The baseline will stimulate discussion and aid in generating appropriate policies and legislation to govern the wise use of the wetlands and biodiversity in Nile Basin Kenya. Issues and recommendations in the book will trigger further research and development that will empower local communities. Scientists yearning for more information can thus reach out and make concerted efforts to improve this knowledge base.

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CHAPTER 2: THE PEOPLE OF NILE BASIN KENYA

Dr.Bonface Oluoch Oindo,
School of Environment and Earth Sciences,
Maseno University, Private Bag Maseno, Kenya

2.1 Introduction

The Nile Basin Kenya is located in the upper reaches of the Nile River Basin. The Basin contains Lake Victoria which draws its water from Sio, Nzoia, Yala, Nyando, Sondu-Miriu and Kuja-Migori Rivers. The Lake Victoria Basin covers an area of 38,913 Km^2 and consists of more than 28 districts in Western and Nyanza Provinces (Figure 2.1). The Lake Victoria Basin supports one of the densest and poorest rural populations in the world, with densities of up to 1200 persons/Km^2. The average population density is 297 persons/Km^2. This is due to its favourable conditions for agriculture, fishing and other economic activities. The growing population, with an average annual growth rate of 3%, exerts increasingly greater pressures on its natural resources. The utilization of these resources is heavily driven by livelihood needs of the inhabitants of the Basin (UNEP, 2006).

2.2 Ethnic composition

The ethnic composition of the indigenous people around the Lake is diverse but they share similar livelihoods. The main ethnic communities living in the Lake Victoria Basin include Luhya, Luo, Kisii, Kuria, Maasai, Suba, Kalenjin and Teso. In the urban centres around the lakeshores, a combination of settlers and indigenous people involved in commercial activities, trading and provision of social services is found. These settlers include Arabs, Indians, Nubians and other ethnic groupings from different parts of the region.

2.3 Culture

The ethnic communities living within the Lake Victoria Basin have rich culture. The numerous cultural sites that dot the Basin provide evidence of this. The Luo and Abasuba of Kenya have very many legendry cultural sites. These were places of significant historical phenomenon or mythical incidents and rituals. Some of these sites are *Simbi Nyaima, Nyamgondho, Luanda Magere, Kit Mikayi, Thim Iye Lich Ohinga* and legendary islands such as *Atego, Ringiti* and *Mbasa na Muole, Nyama ni Ware*. In Mount Elgon, the mountain was a sacred worship place and was considered the place of gods. Among the Bukusu, the Mountain is known as *Masaba* or *Zayuni*. The name *Zayuni* comes from Mt. Zion, the Israelites sacred mountain. Forests were also used for performing religious and customary rituals such as 'Dini Musambua" of the late Elijah Masinde on Mt. Elgon. Circumcision ceremonies are also performed from sacred sites in a forest such Mt. Elgon for Bukusu and Saboati as well as Tiriki in Tiriki cultural Forest. This has assisted in the preservation of such sites. The Bunyore Grooves are used by Bunyore community for rain making. These natural forests are under intense pressure despite concerted efforts for their conservation.

Cultural practices, beliefs and norms in the Lake Victoria Basin are closely linked to natural resources management in the Basin. A number of socio-economic studies have shown that there are gender differences in utilization of natural resources (Ochola *et al.*, 2000). Moreover, Kenya's National Biodiversity Strategy and Action Plan (2000) recognised that gender imbalances exist in biodiversity management and in the utilisation of natural resources. Gender inequality is reflected in women's limited access to land ownership and means of production. Women have difficulties to own land as well as inherit or control family property, especially in the traditional rural setting. Historically, the contribution of women to conservation and development of wetland resources in the Kenya part of the Lake Victoria Basin though great has been marginalized (Gichuki, 2003). The declining wetland resources affect women more adversely than men because they utilize wetlands more than men do for their households' food and medicinal resources. Women fetch water, vegetables, firewood and plant material for making mats, baskets and other marketable products. They also carry out fishing using baskets, reed traps and small seine nets. Women fishers therefore need guidelines to limit interference with the breeding cycle of the fishes caused by removing gravid females, eggs and young through habitat disturbance in shallow wetlands, such as bays and rivers. Traditionally women do not use boats for fishing and hence do not fish in the open Lake. In Lake Victoria Basin, women support their families by using business skills, keeping books of accounts or doing marketing. Marketing of fish, for instance, is a business of women (Plate 2.1). They are also involved in processing and marketing of farm produce, such as fruits, pulses, vegetables and grains. Traditional technologies, which are used by women in rural areas, may fail them because they do not address the differences between men's and women's technological needs, uses and contribution (Appleton and Scott, 1994).

2.4 Sociology, demography and culture

2.4.1 Ethnic groups and traditional socio-economic setting

The main ethnic groups within the Nzoia upper catchment area include the Luyia who together with the Abagusi constitute part of the Western Bantu, the Sabaot, Nandi, Kipsigis, Pokot, and Marakwet Sengwer, Dorobo who are part of the Highland Nilotes.The people of the Olare Onyokie-Kipkaren sub-catchments on Nandi Hills consist of Nandi and Kipsigi cultures. The people of the Moiben sub-catchment on the Cherangani Hills consist of the Marakwet, Sengwer, and Keiyo cultures. The peoples of the Kuywa sub-catchment on Mt Elgon consist of Sabaot, Dorobo and Luyia cultures.

2.4.2 Highland Nilotes - Kalenjins of Rift Valley

The Kalenjin cluster is divided into four sub-groups of the Pokot, the Marakwet of the Rift Valley, the Sabaot of Mt Elgon the Keiyo, Tugen and Kipsigis, Terik and the Nandi make up the Highland Nilotes. These share a common cultural and linguistic heritage. The Highland Nilotes in the upper catchment of the Nzoia include the following ethnic groups: Kipsigis; Marakwet; Sengwer; Nandi; and Keiyo.

Traditionally division of labor is strict among the Nandi, Sengwer, Pokot, Kipsigis, and Marakwet from childhood they were taught to know their proper roles by means of a comprehensive educational system, which operated in the homes and in the wider community. On the whole women cultivated the land and performed all the domestic chores while the men herded the cattle and took care of security affairs. This is however changing and today a large share of herding is done by children. Both men and women milk cows, herd cattle, plant, weed and harvest crops. Men clear the ground of bushes and stumps, cut trees, work iron and make wooden objects and also take the cattle to the salt licks. Women, besides looking after the children, prepare food, fetch water and fire wood, wash milk vessels, clean the house, cattle pen, cut grass, and make clothes and pottery. Resettlement of the large farms in the "white highlands" has led to the co-existence of distinct clusters of Kalenjin with people of other ethnic groups, including Kikuyu, Meru and Kisii.

Table 2.1 Population and poverty of Rift Valley and Western Provinces Districts

District	No of Divisions	No of Location	Estimated Population (2004)	Poor Individuals (2004)
Mt Elgon	4	16	158,529	68,568
Bungoma	10	43	1,029,000	437,779
Uasin Gishu	6	47	731,055	183,780
Marakwet	7	29	165,098	59,000
Nandi	9	91	679,453	268,000
Trans Nzoia	7	26	675,827	240,305
Keiyo	4	26	168,897	53,000
Total	47	278	3,597,859	1,310,432

Poverty levels are high in this region and over 36% of the people living here are poor and mainly depend on the land for food supply and employment.

2.5 *Olare Onyokie-Kipkaren sub-catchments on Nandi Hills*

2.5.1 Kipsigis

The Kipsigis, a sub- group of the Nilotic Kalenjin are the most numerous of the Kalenjin and current population is estimated at 785,000. They occupy the highlands of Kericho stretching north to the Nandi Hills. Land tenure is freehold and adjudicated, indicating that the area was a native trust area during the colonial period. Traditionally the life of the Kipsigis largely centered on wealth in their cattle which remains a major form of wealth. Consequently, cattle and related objects have strong ritual value even today. Currently they practice both cattle rearing and agriculture. Major farming activities in the village are maize production for sale and consumption, livestock keeping, dairy farming and tea growing.

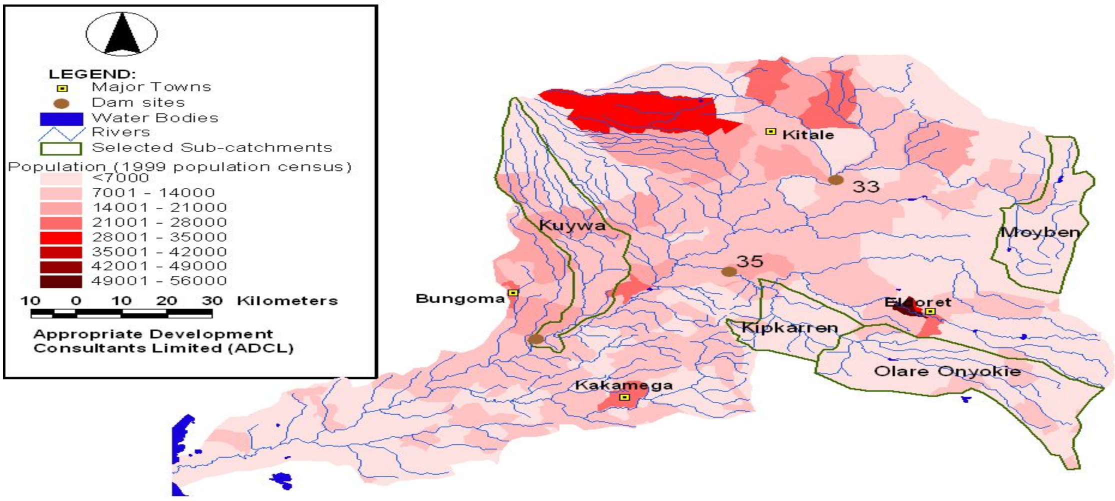


Figure 2.2 Human Population (1999 population census) of Olare Onyokie-Kipkaren sub-catchments on Nandi Hills.

In pre-colonial and early colonial the Kipsigis men had a right to inherit land and livestock. Men's rights to property were circumscribed by the fact that women were regarded as heads of 'houses,' with residual rights of control, and the right to pass land on to their male heirs. Women's status and power were further sustained by their position as producers, processors and traders of food crops. By having sole control over harvested grain, women were vital and contributed in their husbands' prestige and wealth.

Colonization and commoditization led to the privatization of land and the introduction of new crops for exchange. The introduction of maize as the staple food changed the existing division of labor; women continued to cultivate millet on a small scale but maize production and trade with maize came to be regarded as men's 'business'. Since maize was for both consumption and trade, women were obliged to work on their husband's field as helpers. Thus women changed from being autonomous millet producers to being unpaid family laborers. In addition, women's customary rights to the means of production were limited when land adjudication registered land in the names of men. Today, men own and control the land resources. They acquire exclusive rights to productive and reproductive services of their wives through payment of bridal wealth. A man's responsibility is to raise money to cover major household expenses by engaging in income-generating activities and through wage labor. Women's fundamental roles in the household are to provide food, care for the children, carry water, tend cattle, keep the house clean and do whatever the husband wants her to do, e.g. help him in the tea field.

2.5.2 Nandi

The Nandi belong to the Kalenjin cluster. Numerically the Nandi are second only to the Kipsigi among the Kalenjin sub-groups. They inhabit Nandi Hills and surrounding areas from the Mau mountain range on the east and south-east to the Nyanza plans on the west from the Sosiani River in the North to the Kano Plains in South. According to the administrative boundaries they occupy the north and south Nandi districts, Uasin Gishu and Transnzoia districts and the rest scattered in various parts of the country. They practice a clan membership which is patrilineal and members of every clan are found throughout Nandi.

Geographically the southern and western limits of the Nandi plateaus are well defined by granite escarpments rising steely form the plains. Average elevation is 6,000 feet and easy access is available only from the extreme southwest, in which region hills are dotted throughout. The northern region is open grass land with occasional patches of forest in the west and central areas but with hardly any trees on the eastern plains and swampland. The vegetation of the south region varies form dense forest, thorn-tree thickets secondary bush and grass parkland to the sparsely covered hillsides o the edge of the southern escarpments. Below the escarpment the trees are more scattered and stunted and the ground covered with less imitative grass.

Economically the Nandi were pastoralists, cattle being their main interest, with sheep and goats also making their contribution. Currently they practice agriculture and are engaged in maize production. The life of the Nandi people is still largely centered on wealth in their cattle, which remains a major form of wealth. Consequently, cattle and related objects have strong ritual value. Not only is the cow in a sense 'sacred', but milk, dug and grass (item connected to the cow) are also 'sacred' and the status of milk is such that its use is surrounded by a number of taboos.

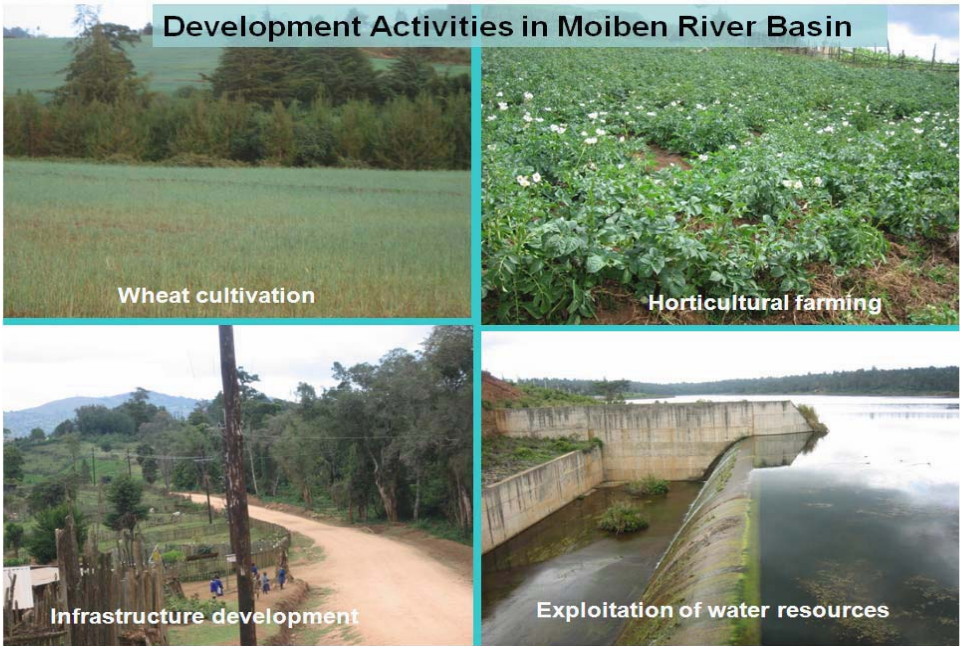
From a cultural view the life among the Nandi is punctuated by a series of rites of passage, from the naming ceremonies connected with the birth through initiations, marriage divorce (when necessary) and entrance to adulthood to final funeral ritual. The most important single event of life is initiation, when a man passes from childhood to adulthood. Traditionally initiation for a Nandi man meant entrance into warrior hood and has continued to function in perpetuating the age set system which in the past was essential to the social and military organization of the people. For the girls to prepare for adulthood and eventual marriage they also underwent female circumcision.

2.6 *Moiben Sub-catchment on Cherengani Hills*

2.6.1 Marakwet

The Marakwet are another sub-tribe of the Kalenjin. They are estimated to number 200,000, which are made up of smaller groups who are the Cherangany (Sengwer or Kimaala), Endwoo, Markweta Sombirir and Kiptaani. They live in the Cherangani Hills rising to 3300m in Marakwet, Trans Nzoia, and Uasin Gishu districts. They live in a highland plateau that rises 2,800 above sea level on the Chebiemit ridges to 3,350 meters above sea level on the Cherangani hills and is covered by forest. The land here also falls in a series of steep scarps that form the Elgeyo escarpment and slopes to the Kerio Valley. This Escarpment forms a main watershed while the east watershed drains to the Lake Turkana the Western part forms part of the Lake Basin and drains into Lake Victoria.

The Marakwet practice mixed small scale farming and keep dairy cows, wool- sheep and chicken. They grow mostly maize, potatoes, beans and vegetables in the highlands. In the highlands they also grow tea and pyrethrum as a cash crop. They traditionally practice furrow irrigation to support crop production along the Kerio Valley.



Development activities in Moiben River Basin today.

2.6.2 Sengwer

The Sengwer are a sub- group of the Marakwet and are estimated to number some 50,000. They are currently engaged in an effort of advocating for recognition as an ethnic group which falls under the category minority tribes like the Elmolo, Ogiek, and Talai. Until recently these smaller groups suffered lack of recognition by the government and by their stronger neighbors leading to loss of group identity. They continue to live as squatters and suffer from evictions by successive colonial and post independence governments.

The Sengwer are closely related to the Ogiek and Dorobo and inhabit the Cherangani Hills in the forests in the upper catchments of the Nzoia including the Moiben sub-catchment. They are mainly cattle herders and dependent on the forest for their livelihood. In 1996 the Sengwer were moved from the forest in Cherangani and 2000 were resettled in Millimani settlement scheme which is a former ADC farm belonging to the government. This has led to the Sengwer having to change their ways of life and begin to cultivation which is a new economy for them. They appear not to have benefited from land adjudication and allocation as only 2,000 Sengwer were settled on the communal land while the rest remain as squatters, living in the public forests.

2.6.3 Keiyo

The Keiyo is a sub tribe of the Kalenjin ethnic group and are relatively small in population estimated at 135,000 living in Keiyo district. They are made up of six clans and these are Kapchemutwa, Irong, Mutei, Rokocho, Tumeiyo, and Metkei. Traditionally the clan solidarity and kinship enabled the Keiyo to live successfully without traditional rulers and bureaucracy, since the Keiyo did not have a distinctive political and administrative system. In the matters of discipline it is the father who is responsible and if there are matters of higher concern he is assisted by the kokwet which is a public gathering of his male age -mates.

Keiyo is a region that is characterized by steep escarpment to the East and the area can be divided into three zones, which include the highland plateau, which rises gradually from an altitude of 2,700 to 3,350 meters above sea level, on the Cherangani Hills. Secondly there is the Elgeyo Escarpment in the intermediate zone and this then gives way to the Kerio Valley. The valley is situated at 1000 meters above sea level and it is a narrow strip that runs for a distance of 80 km and is about 10 km wide.

Economically the Keiyo were livestock keepers in the past but later the economic activities of the Keiyo changed and now they depend on agriculture and livestock farming. In the highlands there is a cool climate therefore they grow maize finger millet, beans, sweet potatoes, vegetable crops, sunflower, tea and pyrethrum. While in Kerio valley they keep livestock for milk, meat, and blood, as well as hides and skins. Livestock is valued by the Keiyo as it is used for sacrifices and ceremonies and was generally valued in the society before the Keiyo adopted agriculture from pastrolism. The Head of the family is the father and he is the one who deals with allocation of land and crops and also the matters of succession.

2.7 Kuywa sub-catchment on Mt. Elgon

2.7.1 Sabaot

These are the predominant ethnic group on Mt Elgon. Their socio-political life is centered on the homestead, with the cattle enclosure and the main house. Traditionally the Sabaot live in a home stead with a group of homesteads that form the Koret. For the purpose of leadership and decision making the koret traditionally has an independent council known as the kokwet where some reasonable form of authority rests and also as a supreme court. It is composed of elders who assume the status by virtue of their wealth and personality in the community.

Among the Sabaot of Mt. Elgon, the family was the basic economic unit. Individual ownership was unknown hence all land belonged to the community. For the successful accomplishment of major economic enterprises such as cattle rearing kinship and kokwet assistance were sought. The possession of livestock remained socially essential as cattle played a primary role in the socio-economic life of the people. They owned large numbers of cattle goats and sheep. Cattle ownership also signified the aggregate wealth and property of an individual in the Sabaot society. Such a person was automatically guaranteed full participation in the social and political life of the community. A man who did not own any cattle could hardly speak at the kokwet for he could not be listened to and could not be a major party in any public business or ceremony. Marriage also involved the payment of dowry in form of cattle. Cattle, was the main support of the people, as they provided milk, blood and meat as well as hides. Agriculture played a very secondary role in the economic system of the Sabaots until recently. Gradually the Sabaots took to agriculture more extensively and has now become a major preoccupation with the growing of eleusine millet, sweet potatoes and maize.

Challenges in Kuywa River Basin.

2.7.2 Dorobo – hunters and gatherers

The Dorobo are a Nilotic speaking group who formerly occupied much of the forested highlands in the west central Kenya, neighboring on the Maasai and Kalenjin. They currently number around 20,000 and are arguably the largest hunter-gatherer community in Kenya. They originally occupied the central Kenya highlands and the forests before the arrival of other communities. Today they occupy parts of the Mau Escarpment Aberdare around the Rift Valley, as well as part of the Mt Elgon in Western Kenya. They live among populated ethnic communities of the Maasai and the Kalenjin and have ended up learning the languages of their neighbors. They are referred to as "Itorobo" by the Maasai, which is a derogative term used for hunters and poor people without cattle. The clan (oret), construed by several local groups, is the land holding unit, and the most important social unit. The Dorobo do not have a centralized leadership institution like chieftainship or political councils. Culture is what has held them together. By destroying the forest or excluding them from access to the forest, their culture is destroyed.

The main economic activity is hunting and honey gathering. For their subsistence they use the forest resources such as firewood, water and food. Gathering the wild fruits, berried, roots and herbal barks for food and medicine was the role of Dorobo women and children. This knowledge was transmitted from one generation to the next. Having lost their traditional livelihoods they now engage in cultivation farming, even though they lack cultivation skills. Currently they are about 3000 and have been resettled in Kopsiro Division of Mt. Elgon District. Although they have been allocated land in Kopsiro in Chepkitale sublocation the men are still found in the Mt Elgon forest moorland where they go to graze their cattle. They continue collecting firewood and water from within the forest reserve. Some 300 men are engaged in pole collection; 30 men continue hunting within the forest; 10 collect honey and less than 10 are engaged in collection of medicine plant.
Former governments have tried to force them out of the forests, allegedly to protect the environment. But the Dorobo pose no environmental threat, but are actually the guardians of these forests since time immemorial. The government has realized that the Dorobo are an autonomous community and they are now being settled in the Mt Elgon Kopsiro Division permanently. The Dorobo had been displaced from their land in 1989 resulting in some dying of hunger. The Dorobo are conservators of the forests and they hold extensive traditional knowledge that should not be allowed to disappear. This traditional knowledge is useful for sustainably managing ecological systems. And their traditional economic system has a very low impact on the biological diversity

2.7.3 Luyia

The Luyia consist of 16 sub-tribes. They occupy Kakamega, Vihiga, Butere-Mumias, Lugari and Bungoma districts in Western Province. In a number of the districts, the different sub-tribes have intermingled such that there are no separate communal settlements. Migratory accounts and minor contrasts in language and custom make it possible to distinguish larger divisions among the Luyia. To a great extent however, they are culturally and linguistically closely related to one another such that a description of the pre-colonial organization of the Luyia easily suits any of these groups. This is because, apart from their linguistic similarities, their socio-political and economic institutions varied much less. Where some variation occurred, it was to be counted on the geographic and climatic dictates of the area occupied by particular sub-tribes.

In pre-colonial Luyialand, the clan was the effective unit of government. The largest political group was the exogamous, patrilineal clans or clan groupings, consisting of one larger and several small clans, but not the whole tribal society. Although numerous forms of cooperation and inter-dependence existed between the different clans of the community (sub-tribes), there was no tribal authority which could overrule clan authority on most issues. The clan was the effective political, social and economic unit which legislated for its people, except for the Wanga Kingdom. Main clan elders appointed a leading influential, wise and impartial elder to take charge of clan affairs of olukongo/oluyia. Such an elder was variously known as omwami/omukasa. These elders ensured the security of clan members, maintained law and order and attended to the general welfare of those they were in charge (Were, 1974). A village (litala) was often surrounded by a fence of euphorbia or lantana. Where enemy raids were common, the villages were surrounded by a wall of clay and a ditch, olukoba running around for defense. Most Luyia communities constructed simple housing structures made up of poles and sticks and plastered with mud. The walls were round with roofs thatched grass or local reeds.

In the pre-colonial Luyia society land formed the focus of social relations. Land, as the major means of production, was communal property. In general land belonged to the whole community and the community controlled its allocation and disposal. Individual members of the community could have exclusive rights over portions of land allocated to them, but such rights were restricted to the rights of access and the use of that land. The communal land tenure system recognized the fact that certain sections of the individual allocations were open for use by the entire community. This included, for instance, grazing fields, the un-cleared forests and those parts not yet cultivated. The other members of the family and the clan could freely graze their cattle in an individual's field. This was effective because people who occupied one fort grazed their animals together for purposes of security. Members of a family or clan utilized common grazing fields, salt-licks and streams to water their animals.

The Luyia society was essentially a patrilineal and exogamous society. Therefore the inheritance of any form of property was clearly defined along male lines of descendants. Basically, the status of sons and daughters differed with regard to the inheritance of family property. From the father a cow or parcel of land was passed over to his sons and later to the grandson. Given the inferior and low status accorded women in the pre-colonial Luyia society, women did not own land per se. Hence a report from the committee that investigated into the system of land tenure in "North Kavirondo" as Luyialand was known by then confirmed this when it stated: A woman does not own land. A girl who has married cannot come back and claim any clan land. As a married woman, she cultivates on her husband's land. When a man dies, his land is divided among his sons and not among his daughters. When a woman dies, the land that she has cultivated remains with her husband. When a man dies his wife is inherited together with her cultivation, by the heir. If the heir is a son he inherits his father's property and provides for his mother (Kenya National Archives file no. DC/NN/10/1. Cited in Nasimiyu, 1985).

During the pre-colonial period, land among the Luyia was used by cultivators for growing subsistence crops. The main economic pursuits of the community were animal husbandry and agriculture. Cattle had both an economic and social value. Cattle belonged to the man and herding was entirely the work of men and grown up boys. However, it has been suggested that a woman had a theoretical possession over all the cattle she milked. If a man had more than one wife, his cows were permanently distributed to all of them. These cows literally belonged to the children of the prospective wives. The possession of a large number of cattle sheep and goats was an indication of wealth. Besides being a symbol of wealth, cattle provided the owner with milk and blood both of which were highly valued among the Luyia society. From milk were derived butter and ghee. Sheep and poultry were usually reared for ritual purposes.

The Luyia pre-capitalist agriculture was a simple subsistence system, growing enough for consumption for one season. The main crops grown include elusine, sorghum, green-grams, simsim, bananas, ground-nuts, peanuts, sweet potatoes, tobacco and vegetables. It has generally been submitted that women were predominantly responsible for agriculture, which in most African societies, with subsistence economy amounted to food production with relatively poor technology. Before the 18^{th} Century, the Luyia used wooden hoes and animal bones for digging and weeding. The bush was cleared by using wooden clubs and trees could be felled by piling wood around their bases and the setting it alight. At a later stage iron hoes made mainly by the Samia sub-tribe of the Luyia. This meant a monopoly of agricultural skills by women. In the pre-colonial period, Luyia women practiced shifting cultivation. The length of time for which an area was worked and then fallowed depended on the types of crops, the soil fertility, the availability and accessibility of other land.

The division of labor was based on sex and age. As already stated women had virtual control and monopoly of crop production. Men helped in the clearing of virgin land, after which women dug the ground, planted, harvested and stored. They also cooked food. This led to the development of rights of women to have the land they controlled for the growing of crops for the maintenance of husbands and their families. To reduce the burden of their work, women are said to have formed weeding groups. Several women in a neighborhood teamed up and worked together on individual plots. This tended to lessen the burden of their as many hands would clear a plot in a short period. The teamwork was also used during harvesting periods and the drying of sorghum and millet before they were finally stored in the granaries. This system of communal labor was more active during peak periods of the agricultural cycle. In order to harvest a large field of finger-millet or sorghum, for example, a man would ask his wife to prepare large pots of beer (made of sorghum or millet). Once the necessary arrangements were finalized, he informed the neighbors as when the harvesting would be done.

Table 2.2 Population distribution in the Luyia and Sabaot settlement districts

District	Male	Female	Total	Household	Square KM
Bungoma	425,957	450,534	876,491	174,838	2,068
Busia	174,368	196,240	370,608	81,697	1,124
Mt Elgon	66,783	68,250	135,033	25,529	944
Kakamega	290,343	313,079	603,422	125,901	1,395
Lugari	105,273	110,647	215,920	41,809	670
Vihiga	232,720	266,163	498,883	105,701	563
Butere-Mumias	227,043	249,885	476,928	107,563	939
Total	**1,522,487**	**1,654,798**	**3,177,285**	**663,038**	**7,703**

Source: District Development Plans

On the material day, all married men and their wives from the neighborhood were expected to appear in the field. It usually customary for them to work for long hours as food was served to them in the field. In the afternoon, they washed themselves and started to drink the beer. This collaborative approach to work suggested that no household existed in isolation (Nasimiyu, 1985). The Luyia and Sabaot are found mainly in the Western province with the Sabaots being found only in Mt Elgon District and the Luyia in Bungoma, Busia Mt Elgon, Kakamega Lugari, Vihiga, Butere-Mumias districts of the Western Province and in Trans Nzoia district in Rift Valley province.

2.8 Cultural factors affecting catchment management

The indigenous forest people who include Dorobo of Mt Elgon and the Sengwer of Cherangani Hills are seen as the guardians of these forests since time immemorial. They understand the value of forests for their livelihood traditionally and have not been a threat to the forests since this is their home. The indigenous knowledge they have on forest conservation and skills on sustainable utilization of forest resources is very useful in the catchment management. The highland Nilotes have cultural practices like circumcision rituals that require them to conserve forests and wetlands for their initiation ceremonies.

Among the Kipsigis, men own and control the land resources. A man has the responsibility is to raise money to cover major household expenses by engaging in income-generating activities and through wage labor. In the absence of gender mainstreaming in catchment management it is the men who would therefore be available to provide labor in conservation efforts because women take care of domestic chores. Among the Luyia, males mainly are the land owners and they control it. Women play the key role of food production and they do not own land apart from women who are separated from their husbands for as a result of death and this would mean that it is the men decide on what should be planted on the farm. The women are restricted from getting firewood from Albizia and Markhamia trees as these are used for timber and are considered to be within the realm of men. Gender mainstreaming should be considered in catchment management to ensure that women are not locked out.

2.9 Migrants, settlers and business people

In the Nzoia upper catchments area of the rift valley province in Trans Nzoia and Uasin Gishu districts there are non-indigenous ethnic groups from surrounding communities since this was a region previously owned by the white settlers. Here the land buying companies from other parts of the country particularly from central province bought the farms and settled their company or group members. The other ethnic groups that have continued to buy land and settle in the districts of Uasin Gishu, Trans Nzoia, North Nandi and South Nandi districts are from Nyanza Province (Kisii, Luo).

During the period of white settlement the Luyia community provided labor on these farms and therefore quickly took over the farms after independence some bought the farms in groups while others bought the land as individuals and they have continued to subdivide this land. Among this community in this region they have a high level of rural to rural migration. Some of the white settlement farms were taken over by the government and were managed by the Agricultural Development Corporation, however most recently these large blocks of lands have been subdivided and allocated to communities who have previously been squatters or landless for example the Sengwer from the Cherangani hills who were previously forest people and now settled in Millimani settlement scheme.

Land buying companies were formed along ethnic lines, thus creating clusters of different cultures living next to each other on the same landscape. This had the effect of weakening traditional systems. As a result people in these areas find statutory laws more functional. A contrasting situation is found in the areas that were designated as native reservations in the colonial era. There are major towns in this region which also have attracted business people from all over the country. The main towns Eldoret, Kitale, Kimilili, have a developed infrastructure (roads, communication, electricity, banks and financial institutions), that influences business development and growth. In Eldoret there are both trade and commerce, and institutions of high learning government and non governmental institutions. Kitale is known as the granary of Kenya and the main businesses are agro- based and other support businesses.

2.10 Gender, marginalized and vulnerable groups

2.10.1 Vulnerable groups – HIV/AIDS

2.10.2 General

Vulnerable groups have become marginalized or disadvantage due to their low/poor social/economic status. Although the region has plentiful natural resources, the current poverty level is high. Those identified as vulnerable include, the poor, women and children, orphans and those infected and affected by HIV / AIDS. The spread of HIV/AIDS is a major concern in Kenya posing a great threat to society destroying any gains made over the years attesting to the fact that the disease has impacted negatively on the economy. Notably the profile of HIV-infected people has been changing and is becoming a disease of the poor with educated people in a position to respond to information available - and adopting safer sexual practices, meaning that the share of the new infections is rising among low income and less educated people. Substantial reduction in poverty levels is the key to subsequent lowering of HIV prevalence rates

Gender is also a factor in HIV/AIDS infection. HIV/AIDS prevalence among women aged 15-49 in Kenya is nearly 9 %, compared to less than 5 % for men in the 15-54 age group, according to a 2003 demographic and health survey. This female-to-male ratio of 1.9:1 is higher than found in most population-based studies in Africa and implies that young women are particularly vulnerable to HIV infection compared with young men. The national HIV/AIDS strategic plan acknowledged that women are more vulnerable to HIV infection than men – largely as a result of women's lower position in the hierarchy of traditional societies, powerlessness and lack of adequate information about the disease.

Table 2.3 HIV prevalence among adults tested; age 15-49(%)

Province	Women	Men	Total
Nairobi	11.9	7.8	9.9
Central	7.6	2.0	4.9

Coast	6.6	4.8	5.6
Eastern	6.1	1.5	4.0
North Eastern	<1.0	<1.0	<1.0
Nyanza	18.3	11.6	15.1
Rift Valley	6.9	3.6	5.3
Western	5.8	3.8	4.9

Source: Central Bureau of Statistics, Kenya demographic and health survey 2003; populations, CBS

Cultural beliefs and practices in this case include female genital mutilation, male circumcision ceremonies, and wife inheritance, belief in witchcraft and burial ceremonies. Among the Sabaot of Mt Elgon, female genital mutilation popularly called FGM is practiced and this is a contributory factor to the spread of HIV during the operation ascribed to poor hygiene and ignorance. After the girls are 'cut' they are 'free' to engage in sex, early marriage (ages 11- 18). This leads to promiscuity and early engagement in sexuality leading to vulnerability to sexually transmitted infections including HIV/AIDS. Male circumcision among the Luyia is conducted for age groups and traditionally the ceremony is carried out for the age group at the same time and same venue, which exposes the boys to poor hygienic conditions and sharing of the circumcision tools therefore leading to infection. A most amazing scenario is now unfolding with the luo of Nyanza Province embracing circumcision after learning that it could aid in reducing HIV infection rates.

Among the Luyia community wife inheritance and widow cleansing is practiced and this has been one way where even those whose husbands have died from HIV related complications; they are cleansed and inherited and as such end up spreading the virus. Furthermore there is the belief the HIV/AIDS pandemic does not exist but refer to deaths from HIV/AIDS related complications as death as a result of witchcraft. It becomes clear that although there are community based groups and NGOs targeting women, OVC and PLWA, no comprehensive practical programmes and projects have been initiated to mitigate and control discrimination of such groups and make them active partners in development. Most of the interventions deal with 'supplies' i.e. providing care, food, clothing, sensitization etc, these tend to increase dependence.

2.10.3 Women as a vulnerable group

Women, especially the girls and orphans are regarded as vulnerable groups especially in poor families because they are exposed to discrimination and exploitation. Gender based violence, rape and child abuse appear to be in the increase. Women and girls are reported to be the main and key caregivers to the OVC and People Living with Aids (PLWA). They spend long hours providing the much needed home-based care for the PLWAs and use their own resources to provide for both groups. Providing such services make the poverty situation even worse since women, the producers now spend much of their productive time offering care services in addition to working in the farms or business. The traditional gender roles over-burden the girl-child, who is expected to assist her mother in household chores and caring of OVC and PLWA. This limits her opportunities for social and economic development, including accessing and performing well in school.

2.10.4 Children as a vulnerable group

Child labour, sexual abuse; beating and mistreatment of children; early marriages; and school dropouts and harmful cultural practices such as FGM and early marriages of young girls is common in rural areas of Mt. Elgon Marakwet, Pokot Nandi and Kipsigis districts. Among the Sabaot, Marakwet, Pokot Nandi and Kipsigis cultural practice of female genital mutilation and payment of dowry, which may lead to early marriages among the poor, continue. Furthermore, poor performance in the schools and high school dropout rates prevail among the girl-child. Although the number of orphans and vulnerable children (OVCs) is not known, it may be assumed that the number OVC is on the rise in the region because of HIV/AIDS related deaths. An effort to educate the people on the rights of the child is being undertaken by some of the organizations like World Vision in Mt Elgon,

2.11 Gender relations and roles

The communities of the Nzoia upper catchment are aware of the natural resources that are available and accessible to them all. These are land, soil and rocks, forests and trees, water (rainfall, rivers, streams, springs, lakes and swamps) minerals. Both men and women are charged with the responsibility to manage and utilize the natural resources and there are defined variations where men own and control the commercial and cash generating resources and women have access to those that are used for producing food. Traditionally it is the men in the Luyia community who plant trees and therefore also control the cutting of trees either for commercial use. Women role is limited to collection of firewood. This has kept the woman closely linked to the utilization and conservation of forests and tree cover in the region without the empowerment needed to plant trees.

Among the Kipsigis and the Nandi the women cultivated the land and performed all the domestic chores while the men herded the cattle and too case of security affairs. This is however changing and today a large share of herding is being done by children. Both men and women milk cows, herd cattle plant, weed and reap crops. Men clear the ground of bushes and stumps, cut trees, and take the cattle to the salt licks. Women besides look after the children, prepare food, fetch Males mainly own land just like in many African countries and it is the landowners who control it. Female landowners are found but this is as a result of either death of husbands or the fathers. Notably although women play the key role of food production it is clear that they do not own land and this would mean that the men decide on what should be planted on the farm. Women are restricted from getting firewood from *Albizia* and *Markhamia* trees as these are used for timber and are considered to be within the realm of men.

2.12 Marginalized groups

The indigenous mountain people who are mainly Hunters and Gatherers at the Chemwa Hills (Elgonis) (said to have moved to the North of the rift valley), the Dorobos of Mt Elgon and the Sengwer community of Cherangani Hills will distinctively have been marginalized by being excluded from most development activities. The communities are found at the upper water catchments of the Nzoia River at the Cherangani hills (Sengwer) and Mt Elgon

(Dorobo). These are important communities in the watershed management as they have indigenous knowledge that relates to utilization of the forest resources on a sustainable basis and the management of their own habitat that can be useful in the implementation of this project. This will include reinstating the indigenous knowledge. Due to social change and economic pressure put on these marginalized groups they have turned against their very source of a livelihood by destroying the ecosystem through charcoal burning and farming. To reverse these practices it is important to engage these communities in alternative sources of livelihood that are income generating project such as Bee Keeping, seeds collecting and tree nurseries and so on.

The Dorobo, of Mt Elgon are currently settled in the Kopsiro Division of Mt Elgon district and this settlement is still on going as they are being moved from the forest in Chepkitale and the Mt Elgon moorland. The Sengwer have been resettled in Trans Nzoia district at Kapolet division and moved from the Cherangani Hills forest area. They have also lost their land to resettlement of squatters from other areas or to environmental conservation.

2.13 Indigenous Knowledge

Indigenous knowledge can be defined as a set of perceptions, information, and behaviors that guide local community members' uses of land and natural resources. Indigenous knowledge is created and sustained by local community members as a means to meet their needs for food, shelter, health, spirituality, and savings. Indigenous knowledge is usually adapted and specific to local ecological conditions and to community members' social and economic situations and cultural beliefs. This knowledge can be simple or complex. It is not static, but evolves in response to changing ecological, economic, and sociopolitical circumstances, based on the creativity and innovation of community members and as a result of the influence of other cultures and outside technologies. Indigenous knowledge reflects a set of neither resource use strategies that may be sustainable in certain contexts, but are not necessarily nor intrinsically so.

A woman selling fish in Kisumu Town

Cultural diversity is closely linked to biodiversity. Humanity's collective knowledge of biodiversity and its use and management rests in cultural diversity; conversely, conserving biodiversity often helps strengthen cultural integrity and values (World Resources Institute *et al.*, 1992). Thus, indigenous knowledge can help promote biodiversity conservation by characterizing resource uses that are appropriate for the particular local landscape. In fact, incorporating indigenous knowledge into conservation and development activities is believed to be an important mechanism for ensuring the most efficient and productive use of natural resources in the short term without jeopardizing them (Warren, 1992).

Indigenous knowledge, particularly in the African context, has long been ignored and maligned by outsiders. The role of nineteenth century colonialism and social science in ignoring and sometimes maligning indigenous knowledge has been well documented (Slikkerveer, 1989). Studies that depicted local communities and their knowledge as primitive, simple and static are now countered by a rapidly expanding data base generated by both biological and social scientists that describes the complexity and sophistication of many indigenous natural resource management systems. The fact that so much effort is now being invested in understanding the basis for indigenous natural resource management indicates that the negative attitudes commonly held about indigenous knowledge during the colonial era have begun to change (Warren, 1992). Today, however, a growing number of African governments and international development agencies are recognizing that local-level knowledge and organizations provide the foundation for participatory approaches to development that are both cost-effective and sustainable. A growing global network of regional and national indigenous knowledge resource centers is involved in documenting the historical and contemporary indigenous knowledge of numerous ethnic groups around the world. Much of this knowledge is at as much risk of being lost as is the case with biodiversity (Linden, 1991). Understanding the indigenous management strategies of farmers and other rural persons that foster diversity in domesticated and wild species can help in the establishment of national programs for *in situ* conservation of germplasm that complement the *ex situ* programs already in existence. To acquire a comprehensive base of knowledge for genetic resource conservation, the genetic establishment must accept a mandate to be concerned not only with germplasm but also the knowledge systems that produce it (Brush, 1989).

Despite their contributions, indigenous knowledge is not adequately promoted and protected in most ethnic communities in the Nile Basin. Indigenous knowledge is being lost at an unprecedented rate, and its preservation, preferably in data base form, must take place as quickly as possible (National Research Council, 1992). For instance, Western Province has varied ethnic groups. The cultural diversity offers potential information that can be exploited to contribute positively to biodiversity conservation. Information on indigenous knowledge has not been well documented and properly packaged to allow, effective dissemination, hence contributing to the massive loss of indigenous knowledge from one generation to the next. The main challenge to indigenous knowledge is the population explosion. Fragile ecosystems are cleared to pave way for human settlements and agriculture. In Nyanza Province, indigenous knowledge and skills like the conservation of shade trees, medicinal plants, shifting cultivation are useful in the management of soil and water and the striga weed. River bank cultivation is also traditionally prohibited and this helps to conserve river banks.

2.14 Natural resources

The perceptions and practices related to the exploitation of the natural resources are closely intertwined with livelihoods and culture (UNEP, 2006). The exploitation of the basins' resources, including water, fish, mining and agriculture, currently dictates the pace and direction of development as well as the vulnerability and overall wellbeing of the inhabitants (Aseto and Ong'ang'a, 2003). Subsistence agriculture, pastoralism and agro-pastoralism currently support about 14 million people in the basin. Fishing is by far the most important economic activity for those living in the lakeshore areas (UNEP, 2006). Tourism is a potential major income earner but Basin inhabitants do not reap the benefits of the income accruing from the industry. This has led to periodic conflicts in some game reserves such as Masai Mara. Besides, the local people have become aware of tourism potential of natural wetlands and have started to establish suitable facilities, such as lodges, museums and cottage industries. There are still many wetlands that retain their natural beauty and can be attractive to visitors. Hence, there is substantial scope to expand the tourism potential and manage the Basin's resources sustainably (Ehlin *et al.*, 1998).

2.15 Knowledge gaps

- There is inadequate knowledge of technological innovations to minimize health risks associated with waterborne diseases. The cultural practices, views and attitudes of local people towards wetlands should be sought and incorporated in wetland management. Their knowledge of wetland biodiversity should also be documented and integrated into the knowledge base of Lake Victoria ecosystem.

- Information on gender and cultural issues affecting wetlands is scanty and has hardly influenced wetland management. In particular the contribution of women and youth to development of wetland resources should be studied.

2.16 Recommendations

- The role of women in natural resource use and development should be recognized and women's skills and innovations strengthened.
- Mainstreaming gender issues in wetland resource management in Lake Victoria Basin requires better understanding of the gendered nature of poverty and how outside intervention can affect their jobs and benefits.
- The sites such as *Simbi Nyaima, Nyamgondho, Luanda Magere, Kit Mikayi, Thim Iye Lich Ohinga* and legendary islands such as *Atego, Ringiti* and *Mbasa na Muole, Nyama ni Ware* can be explored for an integrated and environmentally friendly eco-tourism.
- Indigenous knowledge systems and technologies are not adequately promoted and protected in most ethnic communities in Lake Victoria Basin. There is need to promote indigenous knowledge which promote biodiversity conservation.

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CHAPTER 3: THE WETLANDS

Dr. John Gichuki, Kenya Marine and Fisheries Research Institute and
Mr. Stanley Ambassa, Lake Victoria Environmental Programme, Kenya

3.1 Introduction

Wetland ecosystems are distributed worldwide from the boreal regions to the tropics. The global area of the wetlands has been estimated at 5.8×10^8 hectares, although this estimate is regarded as quite rough (Mathews and Fung, 1987). Saline and /or brackish wetlands comprise approximately 9 percent of the total global wetland area, while the freshwater wetlands occupy the remaining area (Mathews and Fung, 1987; Mitchell, 1990). While relatively small compared to the oceans, savanna or forest area, wetlands have a wide variety of natural functions and benefits which are of value to humanity (Hollis *et al.*,1988) and are biogeochemically active because of their high productivity and redox gradients. Primary production is quite variable among the wetland types (Table 3.1). Salt marshes and mangroves are considered to be among the most productive ecosystems of the world, with estimates of above ground net primary production ranging from 125 to 1500 dry organic matter (gram) per square meter per year (dry $g/m^2/yr$) and the total net primary production reaching more than 4000 dry $g/m^2/yr$. Regarding the inland freshwater wetlands, *Cyperus papyrus* L. (Papyrus) Kenya had an above ground biomass yield exceeding 2060 dry $g/m^2/yr$ (Muthuri *et al.,* 1989; Gichuki, 2003).

Table 3.1. Characteristics of the world's wetlands

Wetland types	Area (10^6 hectares)	Net primary production (dry $g/m^2/yr$)
Freshwater wetlands		
Bogs	297	126-840
Swamps	210	420-2940
Alluvial wetlands	19	420-1680
Saline wetlands		
Mangroves	14	920-4000
Saltmarshes	38	462-3234

3.2 Definition of Wetlands

Wetlands are described as halfway world between terrestrial and aquatic ecosystems that exhibit some characteristics of each (Mitsch and Gosselink, 1993). They have seasonal and fluctuating conditions that make it difficult for one definition to adequately describe all wetland types. However, the recurrent or prolonged presence of water (hydrology) at or near the soil surface is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands can be identified by the presence of those plants (hydrophytes) that are adapted to life in hydric soils such as soils saturated, flooded or ponded long enough during the growing season to develop anaerobic conditions (NAS, 1995; Mitsch and Gosselink, 1993). Wetland plants are adapted to changing redox conditions. The plants often contain air tissues (spongy tissue with large pores) in their stem and roots that allow air to move quickly between the leaf surface and the roots.

The Ramsar definition (Ramsar, 1971) is the most widely used and defines wetlands as areas of marsh, fen, peat land or water; whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salty including areas of marine water the depth of which at low tides does not exceed six meters (UNESCO, 1994). They may, therefore, range from permanent or seasonal lakes, seasonally waterlogged soils, fluviatile systems, and estuarine systems to marine systems. This definition basically covers “natural”, “artificial” and “marine” wetlands as long as the depth does not exceed 6 m at low tide. Whereas the Ramsar (1971) emphasizes on wetlands in regards to their importance as waterfowl habitats, the US Army Corps of Engineers (US ACOE, 1987) and U.S. Fish and Wildlife Service (Cowardin *et al.* 1979) lay emphasis on other attributes such as presence of hydrophytes, hydric soils, and on hydrology. The 1987 Corps of Engineers Manual (US ACOE, 1987) on wetland delineation does not consider unvegetated aquatic sites such as mudflats and coral reefs or vegetated shallow water to be wetland areas, whereas the U.S. Fish and Wildlife Service does (Cowardin *et al.* 1979).

The main wetland types are; peatlands which represents a landscape with a peat deposit that (1) may currently support vegetation that is peat forming, (2) may not or (3) may lack vegetation entirely, the mires which is described as a wetland that supports at least some vegetation, which is normally peat-forming or where peat is currently being formed. This definition explicitly relies on the vegetation. It acknowledges the significance of the peat deposit laid down by past peat formation, but does not explicitly require the presence of a peat deposit (Joosten and Clarke, 2002), the marsh which is defined as a type of wetland which is seasonally or permanently flooded with soils that remain semi-permanently saturated. They are dominated by several species of grasses that are tolerant of salt and anoxic sediments. The main plant species is cord grass *Spartina alterniflora* Loisel., a stiff leafy grass that can grow up to 3 metres in height. It has two growth forms (tall and the short) found in different parts of the marsh. *Spartina maritima* (Curt.) Fern is a native of Europe. Hybridization of the two species formed a sterile species *Spartina townsendii* H. & Groves that later produced a fertile amphidiploid *Spartina anglica* C. E Hubbard (Mitsh and Gosselink, 1993).The bogs are mires (i.e. a peat accumulating wetland) that is hydrolically isolated, meaning that it is fed by water falling directly on it as rain, snow or dew and does not receive any water from the surrounding catchment. Bogs have acidic waters and are often dominated by mosses (Mitsch and Gosselink, 1986). The fens are mires (i.e. peat accumulating wetland) that receive some drainage from mineral soil in the surrounding catchments. Fen peat from a wide range of latitudes and altitudes consist of brown mosses together with roots and rhizomes of Cyperaceae (sedges and saw grasses), grasses and trees.

Minerotrophic peats (fens) are more variable in structure than ombrotrophic peats, reflecting the wider range of substrate conditions influencing them (Joosten and Clarke, 2002).

Lastly, the swamps are a form of terrestrialisation mire named also "Verlandungsmoore" (Joosten and Clarke, 2002). The Schwingmoors are swamps in which peat formation occurs under a floating mat. They are represented by the floating *Papyrus* swamp islands (Symoens *et al.,* 1981). The immersion mires are swamps characterized by peat accumulating underwater on the bottom after the water body has become shallow enough to allow peat producing plants to settle (e.g. many *Phragmites* stands). Papyrus swamps are found in habitats similar to marshes and at their latitudinal limits may even show seasonal variations in growth. According to Bauman (1960) the papyrus plant grows over a wide area bounded roughly by the 38th and 26th parallels on the North and South, and by the 65th and the 32nd on the east and west. However, papyrus reaches its best development in equatorial regions at lake or river edges on a floating mat of detritus. The plant forms the dominant emergent vegetation in most permanently flooded wetlands of tropical Africa (Hughes and Hughes, 1992). No accurate records of the area covered by papyrus swamps exist but one estimate puts it about 20 000 km^2 in Africa (Thompson, 1985). Many African swamps known as the Sudd in Central Africa are dominated by papyrus thickets, which totally block navigation. It is estimated that the Sudd areas of the White Nile and the papyrus swamps around lakes Kyoga and Victoria are responsible for a loss of 50 % of the Nile river water through evaporation and plant transpiration (Thompson, 1976). According to Thompson (1976), *Cyperus papyrus* has a restricted local distribution and is mostly poorly developed when flood regimes consistently exceed 3- 4 m in amplitude, and when localities are subject to flash flooding or very low water levels during the dry seasons. The most extensive papyrus swamps are associated with large shallow lake systems with slow response times during the wet seasons. The distribution is largely associated with flooding duration, but in some cases it will form floating mats of up to 1.5 m thick that are largely independent of the water depth. Papyrus propagates by both seeds and rhizomes (Njuguna, 1982) tolerating annual precipitation of 1– 4200 mm, annual temperatures of 20–30 °C and pH of 6.0–8.5. Papyrus swamps are a relatively simple ecosystem with a single primary producer, no major herbivores and no marked seasonality in primary productivity (Muthuri *et al.* 1989). Papyrus is amongst the largest herbaceous species with culms growing to a height of 5 m and an above ground standing biomass often in excess of 12 dry organic matter (tonnes) per hectares. The culms are topped by the characteristic large reproductive umbel. The stem also contains chlorophyll and has a large surface area. Both the reproductive umbel and the stem are the main photosynthetic surface. The umbel is typically about 50 cm in diameter and consists of several hundred cylindrical rays, each of which extends into three to five flattened (leaf like) bracteoles, the outer points of which describe a spherical form.

3.3 Wetlands of the Nile Basin Kenya

The main wetlands within the Lake Victoria Basin are: the Yala Swamp measuring about 17,500 hectares(ha) with half of this wetland having been reclaimed to grow fish and rice by the Dominion group of companies. The Yala swamp complex hosts three satellite lakes namely: Lake Kanyaboli (1 050 ha), Lake Sare (500 ha), Lake Namboyo (1 ha), 10 000 ha of

Nyando and Sondu- Miriu wetlands, Gucha (Kuja-Migori) swamps, Mogusi/Kimira Oluch near Homa Bay which is scheduled for drainage with the African Water facility having contributed about 2 million dollars for the activity. The Saiwa swamp is the home of the endangered Sitatunga *Tragephalus spekeii*. Other important swamps include the Murula swamp near Eldoret, the Amboseli swamps and Mara river swamps which provide pasture to the teeming wildlife found in this area (Figure 3.1). All the wetlands could be grouped into broader categories as shown in Table 3.2. The riverine or combination of riverine and other type was dominating in numbers out of all the wetlands listed in this report. Man-made wetlands were predominant in Kericho District where dam construction was very prevalent before and after Kenya's independence.

3.4 Wetland services, functions and values

Lake Victoria is a large mass of water that provides important services to over 30 million people in East Africa. The open Lake facilitates transport of people and goods by boats between the Kenyan, Ugandan and Tanzania shores. Its tributaries, rivers Sio, Yala, Nzoia and Nyando constitute essential communication routes for traders and fishermen moving between villages, which are isolated in the fringing swamps. Lakes Kanyaboli and Sare also facilitate communication between people living in or around Yala swamp. The boat traffic and volume of trade in wetlands of Lake Victoria have not been quantified but they are likely to be greater than in designated landing beaches and ports. The wetlands of Lake Victoria offer immense potential for development of nature-oriented tourism, and indeed local tourism is picking up rapidly. Natural wetlands have also been providing services as suitable "field laboratories" for research, education and environmental monitoring. Scientific studies of the natural processes, which lead to the evolution of ecosystem processes such as ecological succession and speciation, such as the extremely diverse cichlids (Kaufman, 1992) in wetlands of Lake Victoria have provided valuable advancement in natural science.

Wetland functions are those activities or actions, which occur naturally in wetlands as a result of the interactions between ecosystem structure and process. Those functions include: floodwater control, nutrient flow, sediment and contaminant retention; food web support, shoreline stabilization and erosion controls; storm protection and stabilization of local climatic conditions, particularly rainfall and ambient temperature. The efficiency of different wetlands in providing these services is generally unknown. Studies on the total (economic) values of East African wetland systems have been summarized by Emerton (1998). The study provides approximate market price of wetlands goods, (products), indirect benefits, optional and existence benefits. The study recognizes that valuation of wetland products and services is partial because some wetland benefits will always be quantifiable and measurable data is not available (Turner, 1991).

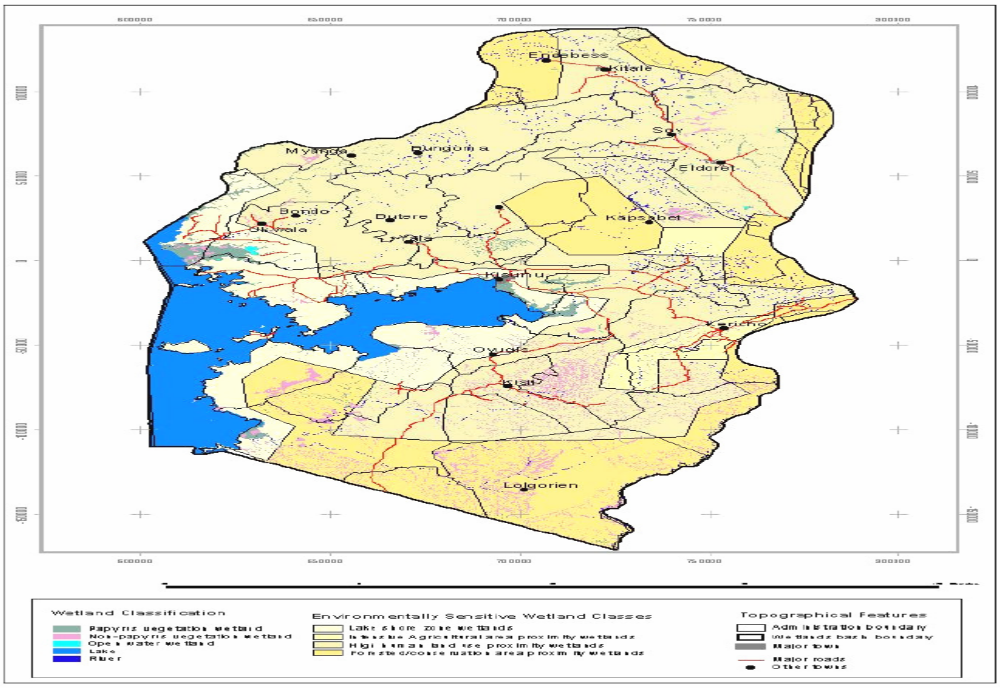

Figure 3.1 Wetland resources in the Kenyan portion of Lake Victoria catchment.

Ndugire (1996) assessed the total economic values of the wetland system by estimating the economic value of key wetland assets, attributes and useable resource stocks. Useable stocks were better understood, appreciated and accorded high economic values by the users. Functional values of wetlands are recognised but few studies have attempted to attach economic values to them both at regional and national level. Socio-economic research on functions and values of wetlands in Lake Victoria is necessary if we have to understand the indirect values and uses of these freshwater ecosystems. M'mayi (1998) using a river basin approach to the study of the buffering capacity of the six major rivers that drain into Lake Victoria found that rivers draining into the Lake have higher values of total dissolved solids (TDS) and electrical conductivity (EC) than the Lake water. This is not surprising, as the amount of nutrient loads released into the rivers is higher due to increased use of chemical fertilizers in the tea and sugar plantations, increased disposal of urban and livestock waste as well as disposal of waste from sugar factories located in the river catchments. The decreased TDS and EC in Lake Victoria water could be attributed to the buffering activity of wetlands. The bigger the wetland, the greater is its ability to sieve suspended solids, absorb chemicals and nutrients in river water. Handa *et al.* (2002) reached a similar conclusion after studying the buffering capacity of River Nyando from Muhoroni to the mouth in Nyakach Bay. How the wetlands remove the nutrients, suspended particles and chemicals from the water is not yet clear. The rivers draining into Lake Victoria carry and deposit a large quantity of silt and organic matter in the floodplain and deltaic wetlands. Swallow *et al.* (2002) report a series of studies that have assessed and monitored sediment load from four main rivers (Nyando, Sondu, Yala and Nzoia). The purpose of the studies was to quantify and trace the sources of the soil carried in these rivers. Samples were taken at 14-day intervals during the rainy season and less frequently during the dry season from headwater, midway and at the end of each river. Turbidity measurements expressed as normalized turbidity units (NTU) were calculated from dispersion of a light beam passed through a column of water. Results for the period between January and November 2001 indicated that River Nyando carried the highest sediment load (527 NTU), followed by Nzoia (294 NTU), Yala (276 NTU), and Sondu (116 NTU). The turbidity values in Winam Gulf ranged between 26 and 36 NTU, thereby making the Nyando sediment load to be 20 times higher than that of Lake Victoria. The Nzoia and Yala rivers carry half as much sediment as the Nyando.

Table 3.2 Classification of wetlands in Lake Victoria Basin based on dominant environment type

Wetland Type
Floodplain
Lacustrine
Lacustrine/Floodplain
Lacustrine/Riverine
Man-made
Modified Wetland
Palustrine
Palustrine/Foodplain
Palustrine/Riverine
Permanent Palustrine herbaceous swamp
Permanent Riverine
Permanent Riverine (edges of Perrenial stream)
Permanent Riverine/Palustrine
Riverine
Riverine/Floodplain
Riverine/Lacustrine/Palustrine
Seasonal Riverine Floodplain

Handa *et al.* (2002) used a Hydro lab (series 4) to measure turbidity, nutrients and other water quality values at different positions between Muhoroni and the mouth of River Nyando. Turbidity was also measured at Nyakach Bay. The results of the period June through September 2002 indicated that high turbidity load of the Nyando originated at Chemilil, suggesting that pollution from the sugar factories and agrochemical fertilizers from the sugar belt contributed significantly to river pollution. Turbidity was highest at Chemilil (496 NTU), followed by Ahero (405 NTU) and lowest at Muhoroni (28 NTU) and Nyakach Bay (39 NTU). These values indicate that River Nyando has very low water quality, which should not be used raw for domestic consumption, especially between the delta and Chemilil centre. Overall, the high sediment load in rivers Nyando and Nzoia probably reflects the erosion from the cultivated hill slopes and devegetation of the riverbanks in the lower reaches of the two rivers. Analysis of nutrient loads during the long rains, April-July 2002, showed that nitrogen and phosphorus levels remained very high in the Nyando, Nzoia and Yala rivers (Swallow *et al.* 2002). The level of Phosphorus (P) in Nyando River was four to five times higher than from Sondu River. Since the soils in the catchment of Nyando, Nzoia and Yala are inherently low in P, the source of high level of P in these rivers should be from farm application of soil chemical fertilizers and livestock waste. Continued addition of water with such a high concentration of nitrogen (N) and P into the Winam Gulf will seriously affect aquatic systems and water quality in the wetlands and in the Lake itself. Eutrophication levels in the floodplain wetlands and in the bays and inlets of Lake Victoria are on an upward trend and may lead to frequent fish kills and water shortage for domestic use. Wetlands in Lake Victoria also receive considerable quantities of waste from urban areas such as Kisumu, Homa Bay and Busia; and from several thousand informal settlements (beach villages), petrol stations, entertainment facilities and other point sources. Sewage treatment facilities in urban centres such as Kisumu, Homa Bay and Busia are either grossly inadequate or absent altogether. Natural wetlands receive and process this raw waste. The contribution of wetlands in water treatment and sanitation has not been adequately studied yet natural wetlands may contribute environmental services worth up to 150 million dollars a year in the Kenyan part of Lake Victoria alone.

3.5 Present situation and trends

Katua and M'mayi (2001) carried out a ground inventory of the major wetlands in eleven Districts of Lake Victoria Basin. Large-scale maps (1:50,000) were used to locate wetlands. Those identified were visited to verify their existence, size, and use by local people and their potential for conservation assessed. The study identified 523 distinct parcels of wetlands, which were linked to the Lakeshore (beaches, estuaries, bays and inlets), floodplains and delta of affluent rivers and streams. The channels of main rivers were fringed by a narrow belt of grasses mixed with reeds as well as small patches of riverine forest. Wetlands in the river catchments consisted of springs, water storage dams, fish farms or ponds and valley bottom marshes. The study recommended a more comprehensive inventory of Lake Victoria wetlands so as to permit detailed mapping of their dynamics and distribution and, for evaluation of their potential for conservation or rehabilitation. The ecological integrity and wealth of natural resources in Lake Victoria wetlands are threatened and have been changing. Human activities in the Lake and surrounding watershed have accelerated the rate of ecological change and increased threats to the existing natural resources. This is true of the catchments that have been deforested to plant coffee, tea, sugarcane, cotton, tobacco and subsistence food crops. Some wetlands in the Lake Basin have been cleared for agriculture and settlements or altered considerably through partial drainage, grazing by livestock, burning and accumulation of silt. The Website of the International Lakes Environment Committee in (ILEC) in Japan outlines the key limnological and natural resource changes that have taken place in Lake Victoria since the 1990s (ILEC, 2001).

The bottom waters of Winam Gulf form a dead zone, devoid of oxygen and fish life. The amount of algae present in the water is 5-10 times more than it was in the 1960's. This is an indication of massive eutrophication (oxygen-depleted condition caused by high nutrient levels), which encourages massive growth of algae, whose death and decay depletes water of its oxygen. Water quality has declined during the last two decades owing to increased flow of nutrients into the wetlands and bays. Nutrient input load has increased by 3-4 times since the 1960's. The concentration of phosphorus has increased in the deeper Lake waters and that of nitrogen around the edges. Enhanced eutrophication has shifted the composition of phytoplankton towards the domination by the potentially toxic blue-green algae. The transparency index of surface water has declined from five meters in the 1960's to one meter in the 1990's. The water in the small bays and adjacent wetlands is highly turbid due to high silt load transported to the Lake by affluent rivers. Water hyacinth, which was absent in 1989 has rapidly spread and choked important waterways and landing beaches in all the shores of Winam Gulf.

Over-fishing and oxygen depletion in the bottom waters of the Winam Gulf threaten the artisanal fisheries and biodiversity. Current evidence on the impact of these activities on the fish fauna indicates that over 200 species of indigenous cichlids are threatened with extinction. Silt and nutrient inputs from the surrounding catchments also contribute to the changes in the biodiversity of Lake Victoria and its fringing wetlands (LVEMP1, 2001). Some areas along the affluent rivers and the shores of the Lake are heavily polluted with municipal and industrial waste discharges. These pollutants as well as ecotone disturbance have serious negative effects on invertebrate fauna, especially molluscs and aquatic insects, such as dragonflies, which breed there. The driving forces of change in Lake Victoria ecosystem are human population pressure, especially its increasing size, rapid growth rate and increasing urbanisation and migration from inland to the shores. They are also linked to the use of inappropriate technology in harvesting of natural resources and economic factors, such as prices of imported and locally produced commodities, unfavorable distribution of family income, poverty and trends in market prices of local products, especially fish, cotton and sugar.

Socio-cultural factors, such as the traditions, lifestyles and informal resource-use rules of the local community have also influenced wetlands perception, use and management. Lack of adequate and appropriate knowledge about the functions and values of wetlands has hindered active management, including rehabilitation of degraded areas by the local community. Inappropriate policy and, weak legal and institutional frameworks have also contributed towards unfavourable environment for wetland conservation and sustainable use.

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Wetland Experts in Kenya

Prof. Frank Muthuri – Kenyatta University
Prof. Stephen Njuguna – Kenyatta University
Dr. Nathan Gichuki- University of Nairobi
Dr Judith Nyunja – Kenya Wildlife Services
Prof George Owiti – Kenya Wldlife Training Institute
Dr. J. Gichuki, R. Abila and Dr.W. Oweke (KMFRI)
Dr. Thuita Thenya- University of Nairobi
Dr. Phillip Raburu and Prof. Okeyo Owuor -Moi University/VIRED
Prof. Joseph Rasowo and Mr. Julius Manyala- Moi University
Dr Moses Ikiara and Dr. Mwakubo- KIPPRA
Prof .J. Mathooko, Dr. N. Kitaka and Dr. J. Kipkemboi – Egerton University
Dr. C. Gichuki, Mrs Jane Macharia, Taita Terer & Dr. Nasirwa- National Museums of Kenya
Mr. Stephen Katua and Stanley Ambassa- NEMA Busia and Nairobi
Mr. Stephen Ambasa, Wetlands Management NEMA Kenya
Mr. Anderson Koyo- KWS
Ms. Margaret Abila- Water Regional Management Authority, Kisumu
Mr. Patrick Gang, DRSRS, Nairobi, Kenya

CHAPTER 4: MICRO-ORGANISMS

Dr. John Gichuki
Kenya Marine and Fisheries Research Institute, Kenya

4.1 Introduction

Microorganisms are found everywhere including the air, soil and water and form part of the many living components of our ecosystem. Microorganisms are categorized into: Bacteria, Fungi and Algae. Wetlands and aquatic habitats provide suitable environmental conditions for the growth and proliferation of the microscopic (micro) organisms. Wetland organisms such as bacteria, fungi and algae are important in the wetland ecosystems because of their role in the assimilation, transformations and recycling of the chemical constituents present in the wetland ecosystems. The wetland microbes may either have the first access to dissolved constituents in the wetlands and either accomplishes the sorption and transformation of these constituents directly or live symbiotically with other plants or animals by capturing the dissolved elements and making them accessible to the symbionts or hosts. This chapter describes bacteria, fungi and algae present in wetland ecosystems of Lake Victoria Basin Kenya.

4.2 Wetland Bacteria

Wetland bacteria are generally classified into the Procaryotea and are distinguished by their lack of defined nucleus with the nucleic material present in the cytoplasm in the nuclear region. Bacteria are classified based on their morphology, chemical staining characteristics, nutrition and metabolism (Kadlec and Knight, 1996). In terms of morphology bacteria are classified into four morphological shapes namely; Coccoid or spherical; Bacillus or rod shaped; Spirillum or spiral; and Filamentous. Bacteria can grow singly or in associated group of cells including pairs, chains and colonies (Table 4.1). They typically reproduce by binary fission in which the cells divide into equal daughter cells. Most of the bacteria are heterotrophic, i.e., obtain their nutrition energy requirements for growth from organic compounds. Autotrophic bacteria synthesize organic molecules from inorganic carbon (carbon dioxide). Some bacteria are sessile, while others are motile by use of flagella. In wetlands most bacteria are associated with solid surfaces of plants, decaying organic matter and soils.

4.2.1 Nitrifying bacteria

The main bacteria mediating the process are *Nitrosomonas* and *Nitrobacter*. These are chemolithotrophic bacteria (use inorganic salts as an energy source and generally cannot utilize organic materials). The oxidize ammonia and nitrites for their energy needs and fix inorganic carbon dioxide (CO_2) to fulfill their carbon requirements. *Notrosomonas are*

Table 4.1 Classification of bacteria important in the wetlands

Group	Representative Genera	Comments
Phototrophic bacteria	*Rhodospirillum, Chlorobium*	Members of these genera are non- symbiotic Nitrogen fixers.
Gliding bacteria	*Beggiatoa, Flexibacter, Thiothrix*	Filamentous bacteria present in activated sludge, *Beggiatoa* oxidizes the hydrogen sulphide.

Group	Representative Genera	Comments
Sheathed baceria	*Sphaerotilus*	These are filamentous bacteria implicated in the reduced sludge setting rates in the sewage treatments plants and common in polluted waters and wetlands.
Budding and /or appendaged bacteria	*Caulobacteria Hyphomicrobium,*	Aquatic bacteria growing attached to surfaces with a hold fast.
Gram negative aerobic rods and Cocci	*Pseudomonas Zooglea, Azotobacter, Rhizobium*	*Pseudomonas* spp, denitrifies nitrite to nitrogen under anaerobic conditions and can also oxidize hydrogen gas. *P. aeruginosa* causes a variety of bacterial infections in humans.*Azotobacter* spp. is a non symbiotic Nitogen fixer. *Rhizobium* is a symbiotic Nrogen fixer
Gram negative facultative anaerobic rods	*Eschericia, Salmonella, Shigella, Klebsiella, Enterobacter, Aeromonas*	*E. coli* is the dominant coliform in feces. *Salmonella* spp causes food poisoning and typhoid fever. *Shigella* spp. causes bacillary dysentery. Species in the *Klebsiella* and *Enterobacter* are nonsymbiotic Nitrogen fixers and are in the total coliform group.*Pneumoniae* is important in the human and industrial wastes and can cause bacterial infections in humans.
Gram negative anaerobic bacteria	*Disulfovibrio*	Reduces the sulphate to hydrogen sulphides in wetlands.
Gram negative chemolithotrophic bacteria	*Nitrosomonas, Nitrobacter, Thiobacillus*	Nitrosomonas catalyze the conversion of ammonium to nitrite. Nitrobacter converts nitrite to nitrate. Ferrooxidans oxidixe the iron suphides producing Fe^{3+} and SO_4^{-2}.
Methane producing bacteria	*Methanobacterium/Archeo bacteria*	Anaerobic bacteria of the wetland sediments that convert carbonate to methane.
Gram positive cocci	*Streptococcus*	Feacal streptococci include human species (*S. faecalia* and *S faecium*) and animal species (*S. bovis, S. aquinus, S.avium*)
Endospore forming rods and cocci	*Clostridium, Bacillus*	*C. botulinum* survives in soils and bottom sediments of wetlands and causes avian botulism. Some *Clostridium* spp are nonsymbiotic N fixers. *Bacillus thuringensis* is an insect pathogen. *Bacillus licheniformis* denitrifies nitrite to dinitrogen oxide.
Actinomycetes and related organisms	*Nocardia, Frankia, Streptomyces*	Filamentous bacteria occurring aquatically and in soils.*Nocardia* spp is implicated in sludge bulking in sewage treatement. Frankia is a symbiotic Nitrogen fixer wit alder trees.

Source: Kadlec and Knight, (1996)

mesophilic, i.e., act at high temperature range (1- 37°C), act at neutral pH and are gram negative, mostly rod-shaped, microbes ranging between 0.6-4.0 microns in length. The field of activity is in the wetland sediments. The bacteria mediates the conversion of ammonia to nitrite

$$NH_4^+ + \frac{3}{2}O_2 \Rightarrow 2H^+ + NO_2^- + H_2O$$

The oxidation of nitrite to nitrate is mediated by Nitrobacter.

$$NH_4^+ + 2O_2 \Rightarrow NO_3^- + H_2O + 2H^+$$

Much of the energy released by oxidation of organic matter is used for CO_2 –fixation via the Ribulosediphophate-Carboxylase (Rubisco).

4.2.2 Denitrifying bacteria

Denitrification is the process of biochemical reduction of oxidized nitrogen with concomittant oxidation of organic matter. The process occurs in intensely anaerobic environment (Figure 4.1).The main bacteria involved are: *Pseudomonas, Escherichia and Micrococus.* The main enzyme involved in this reduction is called Nitrogen reductase with the main co-factors being Iron and molybdenum

$$C_6H_{12}O_6 + 12NO_3^- \Rightarrow 12NO_2^- + 6CO_2 + 6H_2O$$
$$C_6H_{12}O_6 + 8NO_2^- \Rightarrow 4N_2 + 2CO_2 + 4CO_3^{-2}$$

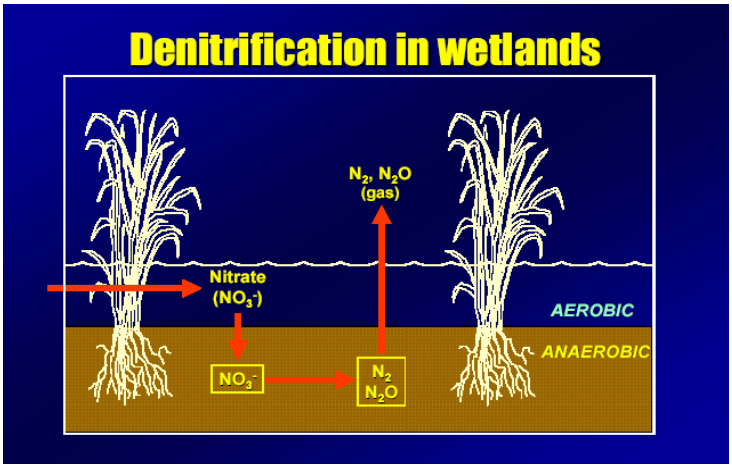

Figure 4.1 Denitrification processes in wetlands

4.2.3 Nitrogen fixing bacteria

Nitrogen fixing prokaryotes operate either anaerobically (*Clostridium, Desulfovibrio, Purple sulphur Bacteria*) or develop special mechanisms such as extremely high respiratory rates (*Azobacter*) and/or cellular features to limit oxygen diffusion, or else develop symbiotic relationships (*Rhizobium*) where the host plant scavenges oxygen. Cyanobacteria, protect nitrogenase in special heterocysts. The heterocysts (bacteria) use these compounds and increase the nitrogen fixing capabilities. The algae nitrogenase activity increases when the (heterocysts) bacteria create oxygen–consuming microzones around the nitrogen – bearing heterocysts. It has been estimated that total nitrogen fixed by biological processes is approximately 1.75×108 metric tons per year. Biological mechanism of nitrogen fixation uses an enzyme complex called nitrogenase consisting of two proteins – an iron protein and a molybdenum-iron protein. The Fe protein gets reduced by electrons donated by ferredoxin. Then the reduced Fe protein binds ATP and reduces the molybdenum-iron protein, which donates electrons to N_2, producing HN=NH. In two further cycles of this process (each requiring electrons donated by ferredoxin) HN=NH is reduced to $H_2N\text{-}NH_2$, and this in turn is reduced to $2NH_3$ (Figure 4.2). Ferredoxin is generated by photosynthesis, respiration or fermentation, depending on the type of organism. Nitrogenase is inhibited in the presence of oxygen.

4.2.4 Sulphur/Iron bacteria

The main sulphur bacteria are of the genus *Thiobacillus* spp. These are colorless gram negative bacteria, rod shaped and move using a polar flagella. Cells are 0.3 × 1 to 3μm in size and are non-spore forming. The bacterium best grows at 25 to 35°C and pH range of 3 to 7. They have ability to gain energy from the oxidation of elemental sulfur and sulfur containing compounds, i.e., utilize sulfur compounds such as thiosulphate to break down organic matter in the wetland. They can also obtain energy through the oxidation of ferrous iron to ferric iron. The genus *Thiobacilli* are obligate autotrophs, i.e., cannot grow with organic carbon as an electron and carbon source. They mediate the process of converting small molecular weight sugars to form hydrogen sulphide.

$$2CH_3CHOHCOO- + SO_4^{--} = 2CH_3COO^- + 2HCO_3^- + H_2S \text{ (gas)}.$$

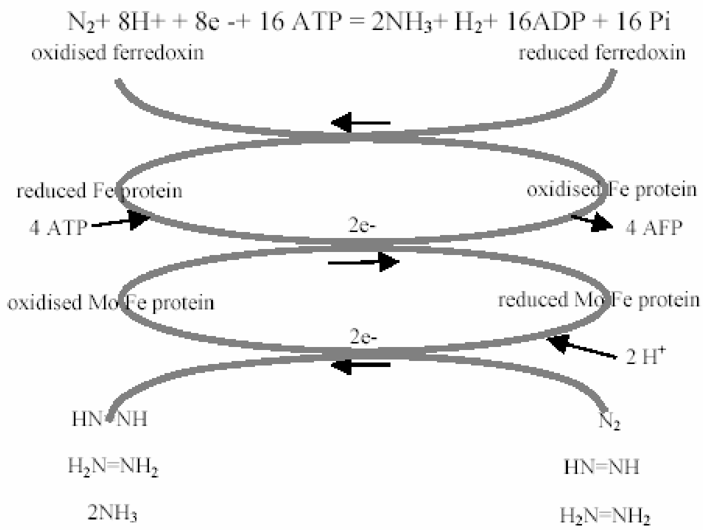

Figure 4.2 The formation of ammonium from nitrogen as mediated by nitrogen fixing bacteria

4.2.5 Methanogens/Archaebacteria

The main bacteria involved in this process are Methanogens or Archeabacteria and degrade organic matter with the end product being methane (CH_4) gas and carbon dioxide (Kadlec and Knight, 1996). They are common in wetlands where they are responsible for methane or marsh gas production as well as in the guts of animals/ruminants. The process is strictly anaerobic since methanogenic bacteria are poisoned by the presence of oxygen at levels as low as 0.18 mg/L. The Methanogenic reactions occur at the redox potential range of - 200 MV.

2 C organic (CH_2O) +$2H_2O$ = CO_2+CH_4 (Gas)

4.3 Fungi

Fungi represent a separate kingdom of eukaryotic organisms that include yeasts, molds and fleshly fungi. All the fungi are heterotrophic and obtain their energy and carbon requirements from organic matter. Most of the fungal nutrition is saprophytic i.e., based on the degradation of organic matter. Fungi are abundant in the wetland environments and play a vital role in water quality improvement. Fungi produce by vegetative methods through spore production or sexually between adjacent mating strains. The main examples of fungi are: water molds (Phycomycetes), Saplolegnia, Rhizophydium (parasitic types), Allomycetes and Basidiomycetes (freshly fungi).

Aquatic fungi colonize niches on decaying vegetation made available following the completion of the bacterial use. Fungi can either associate the higher plants on a symbiotic or pathogenic level. Fungi are symbiotic with species of algae such as lichens and higher plants (Mycorhizzae) thus increasing the host's efficiency for sorption of nutrients from air, water and soil. In wetlands fungi are found growing in association with dead and decaying plant matter. A specialized group of fungi associated with plant roots are the Arbuscular Mycorrhizal (AM) fungi that form symbiotic relationships with most upland plants, but have also been documented on wetland plants (Khan and Belik, 1995). In uplands, mycorrhizae are generally mutually beneficial, with the fungus acquiring carbon from the plant and the fungal network delivering nutrients, especially phosphorus (P), to the plant. Furthermore, elevated soil phosphorus often suppresses the AM symbiosis in upland soils (Graham *et al*., 1982). It is unclear whether the same response to P occurs in wetlands where the nutrient may be more labile under low redox conditions (Rhue and Harris, 1999). The impact of flooding on AM colonization has been studied by others with variable results; some report a negative relationship with redox (Miller, 2000; Jayachandran and Shetty, 2003) while others found no relationship (Brown and Bledsoe, 1996; Van Hoewyk *et al*., 2001). Furthermore, Aziz *et al*., (1995) found no clear relationship between root colonization and plant hydrological category.

4.4 Wetland algae

Most algae are one-celled organisms too small to be seen by the naked eye. They make their food by a process called photosynthesis. Some wetland algae drift on the surface of the water, forming a kind of scum. Others attach themselves to weeds or stones. Some can grow inside plants or animals. Microscopic algae that can be found in saltwater marshes include diatoms and green flagellates. Desmids are a type of green algae found in bogs. Lichens are combinations of algae and fungi. The alga produces the food for both by means of photosynthesis, while it is believed the fungus absorbs moisture from the air and provides shade. One of the most common wetland lichens is called reindeer moss, an important food source for northern animals such as caribou. Cyanobacteria (Blue green algae of the genus *Anabaena* spp) are single celled algae that are able to fix nitrogen from the atmosphere. Cynobacteria possess heterocysts. Heterocysts are main sites of nitrogen fixation. Within the cynaophyte, the number of heterocysts is proportional to the nitrogen fixing capacity of the cynaobacteria. Within a symbiotic relationship, algae secrete simple and complex organic and nitrogen compounds which the heterocysts feed on. The heterocysts (bacteria) use these compounds and increase the algal fixing capabilities. Algae nitrogenase activity increases when the (heterocysts) bacteria create oxygen – consuming microzones around the nitrogen – bearing heterocysts.

4.5 Researches on the use of wetland micro-organisms and wetland environment

4.5.1 Development of constructed wetlands

With the help of large aquatic plants (macrophytes), micro-organisms breakdown human and animal derived wastewater, remove disease-causing microorganisms and pollutants. This has been applied effectively in the development of constructed wetlands. Research indicates that wetlands have a very high efficiency in the removal of enteric bacteria from wastewaters, particularly sewage effluents through natural die-off, sedimentation, filtration, predation, UV degradation and adsorption. In general, wetlands can be designed to remove more than 90 % Biochemical Oxygen Demand, Chemical Oxygen Demand, suspended solids and bacterialolgical pollution through –flowing wastewater. The Removal of N and P remains closer to 50% in most cases (Verhoeven and Meuleman, 1999).

4.5.2 Removal of metals by sulphate-reducing bacteria (SRB) from acid mines

These bacteria are isolated from natural and constructed wetlands. The bacteria, mainly the sulphate reducing bacteria have been used to generate hydrogen sulphide and cause precipitation of metals from solution as the insoluble metal sulphide in mines receiving acid mine drainage. The pH is moderated in these systems by the formation of the hydrogen carbonate ion formed.

$2CH_2O + SO_4^{-2} = H_2S + 2HCO_3$

$M^{+2} + S^{-2} = MS$ where M is a divalent metal like iron II

4.6 Knowledge gaps

The is need for further studies on Malaria Mosquitos and other parasites which have been reported to lay their eggs in still water in the wetlands which are said to provide conducive breeding conditions. The vectors have contributed significantly to push the case for wetland reclamation. Research has shown that these parasites can be reduced sustainably by, for example, using mosquito fish, e.g. *Gambusia* spp. Malarial parasites research is still a challenge; there is needed to identify biological control methods which can accommodative of presence of wetlands.

Changes in water quality and wetland habitats have also affected the micro flora and micro fauna, which constitute an important part of the Lake's food web. The relationships between the various food webs should be investigated and the response of each organism to changes in the presence or absence of the other established.

4.7 Recommendations

Wetland conversion processes should be brought under control by making informed decisions where and where not to convert as well as to restore the important already converted areas. This way we shall protect vital functions, make uses beneficial sustainable and equitable. In addition, the principle of wise use should be applied which states inter alia "The Wise Use of wetlands is their sustainable utilization for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem".

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CHAPTER 5: PLANTS

Dr. Boniface Oluoch Oindo,
School of Environment and Earth Sciences,
Maseno University, Private Bag Maseno, Kenya

5.1 Introduction

The Nile Basin Kenya is endowed with a variety of plant species that are used for medicine, firewood, construction, vegetables and other viable uses. 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*, *Eichornia crassipes*, *Typha domingesis* and *Phragmites australis*. Protection of aquatic vegetation is known to contribute to conservation of fish species diversity. Degradation of the plant community is caused by the demand for land for agriculture and settlement. In the Lake Victoria Basin, the situation is worsened by the high rate of population growth and open access system to areas where these plants occur. Invasion and proliferation of the water hyacinth in the lake is also a threat to the endemic plants during succession.

5.2 Wetland plants

The aquatic plants of Lake Victoria and the surrounding wetlands have been extensively studied. General accounts of the aquatic macrophyte communities in Lake Victoria have been provided by many authors, including Denny (1985a,b,c), Hughes and Hughes (1992); and Harper and Mavuti (1996). The latter noted that the predominant biotic factors that influence the wetland vegetation are local topography and river discharge pattern. The widest zonation of wetland vegetation occurs along the shallow Lake edges, particularly in sheltered inlets, deltas and shores of rivers flowing into the Lake. The deltas of Rivers Nyando and Sondu-Miriu provide good examples of sites with a wide zonation of wetland plants. Gichuki *et al*. (2001) investigated the ecology of macrophytes and their role in the economy of Sondu river delta. They identified 34 plant species, which were subsequently classified as emergent, floating leaved, free floating and submerged. The major plant groups were *Cladium jamacanse, Cyperus papyrus* and C*yperus latifolius.* The common emergent macrophytes in Yala Swamp and Nyando Delta are grasses such as *Echinochloa pyramidalis* which occupies seasonal wetlands, reeds *(Phragmites kirkii*), sedges *Cyperus papyrus* and *Typha domigensis* and tall water grasses such as *Paspalidium geminatun* and *Vossia cuspidata* (Handa *et al.* 2002.*)* The latter occupy permanently inundated wetlands.

Surface floating macrophytes include the duckweed *Lemnia spp*., water ferns *Azola spp.,* water cabbage *Pistia striotiotes* and water hyacinth, *Eichornia crassipes*. Since 1995 there has been a prolific growth in the studies of water hyacinth in Lake Victoria (Plates 5.1 & 5.2). The invasion of the weed and its subsequent spread in the Lake during the last eight years has contributed significantly to changes in water quality, ecology and fishery as well as to the biodiversity of the Lake in general. Water hyacinth forms dense mats on the Lakeshore and bays, beaches and mouths of affluent rivers. This aquatic weed thrives in sheltered areas but it is migratory as it is moved by wind. Dense mats, block landing beaches, bays and inlets, thereby making access to the shore by boats extremely difficult. As the weed moves it influences the distribution of small fishes, birds and invertebrates that are associated with it.

Water hyacinth, *Eichornia crassipes* mass on Lake Victoria.

Morphology and structure of water hyacinth, *Eichornia crassipes*.

Invasion of the shoreline by water hyacinth eliminates an important feeding *niche* for thousands of shorebirds and nesting sites for the Nile crocodile, *Crocodile niloticus.* These changes have ramifications in all aspects of biological and human life in Lake Victoria and the surrounding wetlands (Plate 5.3). Water hyacinth is a major problem in Lake Victoria and is responsible for rendering the port inoperable for periods of time severely limiting fishing and blocking the municipal water intake. Mechanical control has mostly been unsuccessful since the weed grows faster than mechanical clearance can cope (Plate 5.4). Various herbicides are also effective but have significant risks for other wetland biodiversity. However, both methods have been successfully used in Uganda and Tanzania. The Kenya Agricultural Research Institute (KARI) introduced more than 200,000 weevils into the lake to feed on the weed (Plate 5.5) which succeeded in reducing its spread.

Effects of water hyacinth on human activities on the Lake Victoria.

Water Hyacinth mechanical control method

Submerged plants, which include *Najas* spp., *Potamogeton pectinatus* and *Ceratophyum demersum,* are extremely sensitive to changes in water quality, especially due to chemical pollution and suspended sediment in bays and rivers flowing into Lake Victoria. Similarly, the floating-leaved macrophytes, which are rooted in the bottom sediments but with leaves floating on the water surface, are negatively affected by water pollution and high turbidity. These plants include water lilies (*Nymphaea caeruleus and Nymphaea lotus*) and potamogetons (*Potamogeton thunmbergii)*. Examination of April 1988 aerial photographs of Nyando Delta and Nyakach Bay and ground inspection in February 2003 indicated that water lily mats at the mouth of Nyando River had shrunk by nearly 86% of their size in 1988. This loss could be attributed to invasion of the estuary by water hyacinth and prolific grasses such as *Vossia cuspidata* and increasing sediment load of the river (Gichuki, 2003).

Water Hyacinth biological control methods using weevil, *Neochetina eichhorniae* Warner, which were applied during Lake Victoria Environmental Programme 1.

The hydric soil (which is subject to water logging) of wetlands is saturated, flooded, or ponded, and tends to develop anaerobic conditions in the upper part (Miller and Gardiner, 1998). The hydrophytic plants that grow in wetlands have adaptations that allow them to survive in inundated soil with limited oxygen. Some of these adaptations are adventitious roots, stooling and buttressing of plant bases. Some of the characteristic plant species that thrive under those conditions in Lake Victoria Basin are Bulrushes *Typha domigensis*, Papyrus *Cyperus papyrus* and Elephant grass *Echinochloa pyramidalis* (Thomson, 1985). In recent years, rapid expansion of grasses and reeds from the landward side has significantly reduced the abundance of papyrus in Lake Victoria (Handa *et al*., 2002). Moreover, the papyrus endemics, such as the Papyrus Yellow Warbler, Papyrus Gonolek and the Speke's Sitatunga are displaced when papyrus beds are over harvested for basketry or burned or cleared to pave way for agriculture. Kirugara and Nevejan (1996) suggest that enhanced sedimentation on the Lakeshore and silt deposition on the floodplains could be responsible for the observed plant succession. Grasses, especially *Vossia cuspidata* and reeds *Phragmites mauritanious* presently dominate the Nyando and Sondu-Miriu floodplains. In addition, burning, clearing and grazing of wetland vegetation have made a significant contribution to overall changes in wetland plant communities in the Kenya part of Lake Victoria Basin.

5.3 Restoration of degraded wetlands vegetation

Increased human population in Lake Victoria Basin from 8.4 million in 1989 to almost 12 million in 1999 and the reduction of the Lake's fishery have increased pressure on wetlands. There has been growing encroachment of wetlands by farmers especially in the Basin of rivers Sio, Nzoia, Yala, Nyando and Sondu. The local community have burned or slashed wetland vegetation to create land for farming, abandoning exhausted sites (Gichuki, 2003).There were several patches of wetlands that had been abandoned by farmers in Nyando delta and flood plain in February 2003. Further, some of the land reclaimed from Yala Swamp for agriculture and settlement in the early 1980s was abandoned for 5-7 years but its recovery, as a wetland community has been negligible. Degraded wetlands should regenerate naturally once left fallow (Gichuki, 2003). There were also limited attempts to rehabilitate polluted wetlands at the mouth of River Nyamasaria and Kisumu bay. Sediment traps were placed along the river channel. This polluted river was also seasonally cleaned by natural floodwaters from the local catchment. Eutrophication of Kisumu bay was considerably reduced after the invasion of the bay by dense water hyacinth mats. The degraded wetlands were characterized by the presence of few but abundant plant species. For instance, grasses, such as *Vossia cuscidata* were dominant in areas where papyrus sedges had been cleared through cutting or burning (Gichuki, 2003).

5.4 Knowledge gaps

Lake Victoria wetlands play an important role in buffering the Lake against pollution. However, it is not clear how vegetated wetlands remove pollutants from water. The factors that influence the efficiency of wetlands in pollutant removal are also not well understood in tropical environments. The buffering capacity of wetlands in Lake Victoria should be investigated with a view of enhancing or restoring their performance. The impact of disposing urban and industrial wastes on wetlands flora should be investigated to reduce the risks of overloading the natural wetland system and driving vulnerable species to extinction.

5.5 Recommendations

1. Productivity of wetland plants has been investigated in some emergent macrophytes, especially papyrus. There is however need to investigate and document productivity of other species.

2. The sedges and grasses found in the wetlands are highly productive and can be harvested and preserved as livestock fodder or to make compost manure by farmers.

3. There is need to assess the plant biodiversity, measure productivity and assess its role in nutrient cycling in wetlands.

4. In addition, innovative ways of utilizing wetlands without damaging the ecosystem should be developed and promoted among the local communities.

5. Invasive species, such as water hyacinth, water lettuce and woody shrubs have invaded some wetlands, especially in Yala and Sio river flood plains. Research

should be carried out to determine the extent of the infestation and its impacts on fisheries and other organisms that typically inhabit papyrus and grass beds.

6. Documented case studies of deliberate wetland rehabilitation in the Lake Victoria Basin are extremely scarce. It is imperative that the impacts of wetland resource use by people and livestock be studied in detail so as to inform management and rehabilitation strategies.

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Wetland Plants Experts in Kenya

Dr. John Gichuki, Kenya Marine and Fisheries Research Institute, Kisumu.
Mr. Tsuma Jembe, Kenya Marine and Fisheries Research Institute, Kisumu.
Dr. Arthur Ochiel, Kenya Agricultural Research Institute, Kibos station, Kisumu.
Geoffrey Netondo, Maseno University, Maseno, Kenya.
Dr. Boniface Oluoch Oindo, School of Environment and Earth Sciences, Maseno University, Kenya

CHAPTER 6: INVERTEBRATES

Dr. Richard Bagine and Dr. Celicia Gichuki,
National Museums of Kenya

6.1 Introduction

One of the largest groups of fauna associated with wetlands is the invertebrate group. Invertebrates are animals without a back bone. They are the most numerous and diverse creatures on earth. About 97% of all animal species are invertebrates and live in terrestrial and aquatic environment. They play a critical role in the functioning of ecosystems such as nutrient cycling, food webs, among others. Aquatic invertebrates live at least part of their life in fresh water ponds, lakes, streams or rivers. For example, benthic invertebrates live under water hiding in between bottom rocks and plants in the mud. Aquatic invertebrates belong to several animal phyla. The most important ones are Protozoa (flagellates, amoebae, ciliates, etc.), Porifera (sponges), Cnidaria (e.g. Hydrozoa), Platyhelminthes (living flatworms, i.e. non-parasitic), Annelids (e.g. Leeches and Oligochaetes), Mollusca (e.g. Snails and Bivalves) and Arthropods (e.g. crustaceans, spiders and insects). The class insect (Hexapoda) comprises the aquatic beetles, dipterans flies, etc. Mayflies, water bugs, dragon flies, stoneflies and caddis flies, etc. are numerous in aquatic ecosystems. For example Diptera (flies) are 40% of all fresh water insects. The aquatic invertebrates constitute an important component of wetland biodiversity in Lake Victoria Basin. They play an integral role in the production dynamics of wetlands, aquatic food web, bio-control agents, bio-indicators and as vectors. Unfortunately, the knowledge of aquatic invertebrate especially in Kenya and East Africa in general is scanty. Few studies carried out on important aquatic invertebrate have focused on economically important species, control of vectors, production ecology and biosystematics. For instance, Cooper (1996) carried out reviews and studies on the diversity, taxonomy and functional groups of aquatic invertebrate community within the Lake Victoria Basin. The composition and abundance of benthic macro-fauna was studied in detail by Mothersill *et a*l., (1980). The relationship between the diversity and abundance of macro-invertebrates and changes in water quality in Nyando River were studied by Handa *et al*., (2002).

6.2 Previous and ongoing research in Lake Victoria Basin

The institutions and individuals who have carried out research in Lake Victoria focus mainly on different ecological and socio-economic issues. They also address environmental problems, management constraints and where convenient investigate scientific curiosities. On the other hand, very little is being carried out on aquatic inventory, conservation, biosystematics and the role of invertebrates in wetland ecosystems. Kenya Marine Fisheries Research Institute (KMFRI) co-ordinates and carries out research on fisheries biology, fish stock assessment as well as studies on invertebrates, wetland plant communities and to some extent water quality and pollution. The Lake Basin Development Authority (LBDA) carries out research on water quality, fisheries, aquaculture, water borne diseases and improvement of wetland products. The Kenya Medical Research Institute (KEMRI) undertakes research on water related diseases such as Malaria, Schistosomiasis, cholera and human skin diseases. Their studies on disease vectors such as snails, Anopheles mosquitoes and simulid flies as well as the prevalence and mode of transmission of the disease agents takes the highest priority. The National Museums of Kenya is the key player in biological, socio-economic and cultural studies in Lake Victoria Basin, e.g. the impact of human activities on genetic patterns of snails that carry vectors of schistomiasis and buffering capacity of Nyando delta is currently ongoing. The biodiversity research in Lake Victoria focuses on generating basic ecological data, developing sustainable bio-indicators (e.g. diatoms) of the aquatic environment, developing tools for biodiversity monitoring, and promoting conservation of wetlands and the associated culture among the local communities.

The Kenya Wildlife Service has been carrying out and coordinating biodiversity research and conservation work on wetlands. Work on biodiversity indicators for National use (B/NU) and through Nyando wetland conservation programme community based research and conservation have been promoted. The Lake Victoria Environment Management Programme (LVEMP) regional programme focuses on fisheries water quality, aquatic weeds control, wetlands management and capacity building. The then National Environment Secretarial (Ministry of Environment and Natural Resources) Project Staff were involved in wetland inventorying in Lake Victoria Basin and buffering capacity of wetlands studies in Sio, Nzoia, Yala, Nyando and Sondu-Mirui rivers. Several individual research projects/programmes on Lake Victoria Basin have been carried out by scientists from National Universities and other international professionals. These studies have focused on biodiversity uses, threats and conservation. Other studies have looked at fisheries, hydrology, water quality, wetlands and socio-economics of natural resource use.

The impact of water hyacinth, *Eichhornia crassipes* (mart) solms on the abundance and diversity of aquatic macro-invertebrates along the shores of northern Lake Victoria have been studied by Masifwa *et al.* (2001). On the other hand, Mwebaza-Ndawula (1994) investigated the changes in relative abundance of zooplankton in the same region. Reviews and studies on the diversity, taxonomic and functional groups of aquatic invertebrate communities within the Lake Victoria Basin were carried out by Cooper (1996). Other investigations carried out on macro–invertebrate's fauna focused on their ecological role in the production dynamics in the lakes, e.g. Mavuti and Litterick, (1991). Studies of the relationship between the diversity and abundance of macro-invertebrates and changes in water quality in Nyando River were undertaken by Handa *et al*. (2002). This provided valuable insights into the response on invertebrate communities to changing river water quality.

6.3 Knowledge gaps

Knowledge of aquatic invertebrate fauna especially in East Africa is scanty. This is also true in Lake Victoria Basin and its catchment areas. Few studies carried out have focused on economically important aquatic invertebrate species. Detailed research studies targeting specific aquatic invertebrate group (taxa) in Lake Victoria Basin are limited. It is, therefore, important to investigate what kinds of aquatic invertebrate species there are, their distribution and composition. There is need to carry out biodiversity surveys and inventories in Lake Victoria Basin wetlands. Modern technology such as satellite imagery and Geographical Information System (GIS) should be used to carry out a quantitative physical inventory of wetlands and their invertebrates in Lake Victoria Basin. The aquatic invertebrate species are good indicators of environmental conditions, for example, water pollution, water quality and climate changes. Scientific studies targeting these key areas are crucial. Most of the Lake Victoria Basin wetlands are invaded by exotic weed species e.g. water hyacinth which affect the production of wetlands and inhibits movement. All sorts of methods such as mechanical (physical), chemical and biological control have been used either singly or in combination to eliminate the invasive species. The biological control methods are environmentally friendly and further work on aquatic bio-control agents, their biology and ecology should be carried out.

6.4 Recommendations

- Regional collaborations need to be strengthened to focus on research, monitoring and conservation.
- Develop an effective water-quality monitoring system involving key indicators and intolerant invertebrate species that disappear in the degradation sequence of an ecosystem.
- Attempt to establish a detailed data base for all the information available on aquatic invertebrates of Nile River Basin.
- Focus on aquatic invertebrate research themes that target specific groups and species of economic importance e.g. invasive alien species, vectors, bio-agents, etc.
- Promote well coordinated aquatic surveys and inventories are undertaken by expert institutions and individuals.
- National and perhaps regional wetland policies should be concluded to secure the wetlands ecosystems and their valuable resources. Such policy formulations should involve all stakeholders at every critical stage.
- Development of the culture to freely exchange information, ideas and findings with stakeholders nationally and regionally is worthy establishing including modalities of transmitting such information to end users.

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Aquatic Invertebrates Experts in Kenya

George Sikoyo – Focus on macro invertebrates of Lake Victoria ecosystem
Lange Charles – Snail ecology and biosystematics
Mavuti, K. – Ecological aspects and productivity of wetlands along Yala swamp.
Shivoga, A. W – Focus on invertebrate communities in streams

CHAPTER 7: FISHES

Dr. W. O. Ojwang and Mr. J.E. Ojuok,
Kenya Marine and Fisheries Research Institute

7.1 Introduction

The fishes of Nile Basin Kenya were four decades ago considered by many as one of the most species assemblages in the tropics. Historically the fish species of the Nile Basin in Kenya were predominantly composed of haplochromine cichlids and over 38 non-cichlid species. Taken together, there were over 14 different fish families including: Protopteridae, Mastacembalidae, Schilbeidae, Mochokidae, Mormyridae, Cichlidae, Bagridae, Cyprinidae, Cyprinodontidae, Centropomidae, Cyprinidae, Amphilidae, Amphilidae, Characidae and Anabantidae in the Lake Victoria system (Table 7.1). But in the recent past, some of the fish species, particularly the piscivorous guild of the haplochromines are feared extinct, well before they are even described to the rest of the world. The nostalgic mass migration of the indigenous riverine (potamodromous) fish species *(Labeo victorianus* and *Barbus altianalis*) is now an almost forgotten phenomenon in the lake Basin. The decline and the near disappearance of some fish species is attributable to multiple introduction of exotic species (*Lates niloticus*, *Oreochromis niloticus*, O. *leucostictus*, *Tilapia zillii* and *T. rendallii*). Moreover, several anthropogenic activities, including wrong fishing methods have impacted negatively on the system and negated any efforts towards sustainable exploitation and conservation fish species of the Nile Basin Kenya.

7.2 Fish species composition and distribution in the Lake Victoria Basin

The Nile Basin in Kenya is a mosaic of different habitats and realms: the pelagic and littoral compartments, satellite lakes, rivers, dams and swamps. Together the system hosted one of the most speciose fish communities in the world. The celebrated diversification of haplochromine cichlids in this lake may have owed much to the spatial layout and temporal dynamics of the Lake Victoria watershed (Seehausen *et al.,* 1997; Kaufman *et al*., 1997). The fish fauna of the lake's watershed is essentially of Nile origin, but there are many endemic species. According to Greenwood (1965) the system contains over 177 species of fish, of which 127 are cichlids. Greenwood (1974) also reported 38 non-cichlids, 16 of which are endemic, split between five orders. Among the native fishes include the Cichlids, Cyprinids, Catfishes, Lungfish and Mormyrids. Recent taxonomic work in Tanzania, however, indicates over 500 species of Haplochromines. The web based site, the FISHBASE puts the number of native, endemic and introduced fish species of Lake Victoria Basin at 223.

Table 7.1 Fish species and percent occurrence in 23 sampled stations in Lake Victoria, Kenya

Family	Species	Percentage occurrence
Cichlidae	*Oreochromis niloticus*	100
	Oreochromis leucostictus	5.8
	Tilapia zillii	11.6
	Tilapia rendalli	5.8
	Xystichromis sp.	17.6
	Yssichromis laparogramma	76.4
	Yssichromis fusiformis	58.8
	Astatotilapia sp.	5.8
	Paralabidochromis'rock kribensis	5.8
	Paralabidochromis chilotes	11.6
	Paralabidochromis plagiodon	11.6
	Paralabidochromis sp.	5.8
	Ptychromis sp.	11.6
	Other Haplochromines	100
Mochokidae	*Synodontis afrofischeri*	17.6
	S.victoriae	17.6
Schilbeidae	*Schilbe intermedius*	23.5
Clariidae	*Clarias gariepinus*	52.9
Propteridae	*Protopterus aethiopicus*	17.6
Cyprinidae	*Rastrineobola argentea*	5.8
	Barbus profundus	5.8
	Barbus neglectus	5.8
	Barbus jacksonii	5.8
Characidae	*Brycinus sadleri*	52.9
	B. jacksonii	11.7
Centropomidae	*Lates niloticus*	100
Mormyridae	*Mormyrus kannume*	5.8
	Gnathonemus longibarbis	5.8
	Marcusenius victoriae	2.6
Bagridae	*Bagrus docmac*	5.8
Mastacembalidae	*Aethiomastacembelus frenatus*	2.6
Anabantidae	*Ctenopoma murie*	5.8

Source: Masai *et al*, 2005)

7.2.1 Introduced fish species

In order to compensate for the dwindling catches, particularly of the popular native tilapiine *Oreochromis esculentus*, four species of non-indigenous tilapiines were introduced to the lake: *Oreochromis niloticus* Linnaeus, 1758, *O. leucostictus* Trewavas, 1933, *T. zilli* Gervais, 1848 and *T. rendalli* Boulenger, 1897. In 1954 came the first of a series of concerted efforts, ultimately successful, to introduce another non-native species- the huge, predatory Nile perch, *Lates niloticus* (Hughes, 1986; Ogari and Dadzie, 1988).

Other introduced species albeit unsuccessful include the reported presence of *Micropterus salmoides* (Largemouth Bass) and *Anquilla anquila* (European eel) in river Sondu/Miriu (Manyala, 1999) and Lake Victoria respectively. Other non indigenous species showing remarkable presence in the lake Basin includes *Pseudocrenilabrus multicolor* (Egyptian mouth brooder) and *Poecilia reticulata* (Guppy).

7.3 Fisheries of Lake Victoria, Kenya

Recent research surveys (Masai *et al*., 2005) in the lake recorded a total of 37 species, representing eleven (11) families (Cichlidae, Cyprinidae, Mochokidae, Schilbeidae, Centropomidae, Protopteridae, Clariidae, Bagridae, Mormyridae, Mastacembalidae and Characidae). The pelagic haplochromines, (*Yssichromis laparogramma* and *Y. fusiformis*) were mainly restricted to stations of more than 4 m depth. Table 7.1 shows species distribution in the 23 sampled stations in the Kenyan portion of Lake Victoria. *Lates niloticus* was the most widely distributed, occurring in all the stations. *O. niloticus* occurred in 73.9%, while *Rastrineobola argentea* and haplochromines only found in 65.2% of the sampled stations. Although a number of indigenous species are still being recorded in the lake, the two introduced species (*Lates niloticus* and *Oreochromis niloticus*) and the indigenous cyprinid *R. argentea* currently form the backbone of the commercial fishery. However, in recent times intense fishing pressure and other environmental factors have continued to affect the total landings of these species as seen in Figure 7.2.

Detailed analysis of the catch trend reveals four marked fish catch regimes since 1976. 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 (Hughes, 1986; Abila, 2005). The 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). The declining catches are largely attributed to the use of small mesh nets, indiscriminate gears and mass-target fishing methods, which have been prevalent in Lake Victoria.

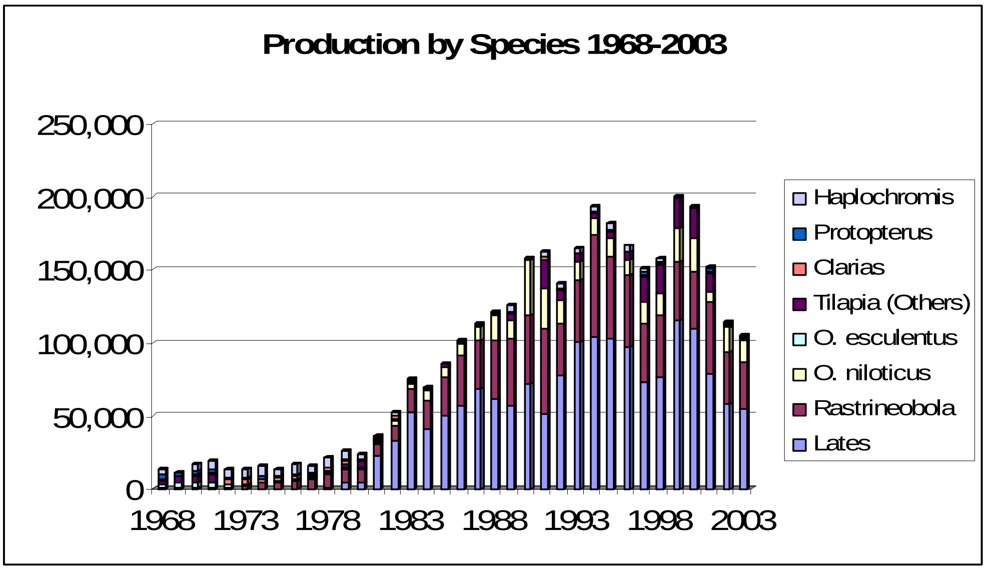

Figure 7.2 Annual catches (metric tons) from the Kenyan waters of Lake Victoria (1968-2003). Source: KMFRI.

In particular, there has been a gradual reduction in mean mesh sizes of gillnets used in the lake in the last decade. The other two commonly applied stock assessment indicators – mean catch sizes and catch per unit effort – have also generally declined in the past decade. The mechanized, few species and mostly export fishery of today presents a stark contrast to the artisanal fishery on at least a dozen prized native food fishes of three decades ago. But as reported by Ojwang, (2006) and Ojwang *et al. (*2007), all is not lost. Diverse habitats; rocky shores and offshore islands, swamps, rivers, satellite lakes and dams still support relict populations of some of the native fish species, representing potential seeds of resurgence.

7.4 Satelite lakes, dams and swamps

The other habitats of the Lake Victoria region that continue to draw lots of attention for their conservation and research potential are the numerous satellite lakes and dams commonly known as small water bodies-SWB (Greenwood, 1974 & 1981; Mwanja *et al*. 2001 & 2004; Kaufman and Ochumba, 1993; Balirwa *et al*, 2003). The discovery of some of the extinct taxa in Lake Victoria as extant representatives in the satellite lakes and dams was a big relief to both conservationists and evolutionary scientists. The existence and the survival of the remnant species have since been used as leverage for continued campaigns for the protection of some of the water bodies and use of the SWB as *in situ* evolution laboratories. The potential of SWB populations as seeds of resurgence was noted as early as 1965 by Greenwood who postulated that the satellite lakes might act as nursery beds, delivering new prototypes that move into the larger systems. He proposed that SWB could act literally as boiler plates for speciation and thus speed up the multiplication of cichlids. SWB are also important refugia for indigenous fish species other than the cichlids.

Table 7.2 Checklist for fish species in rivers of Lake Victoria Basin, Kenya. P stands for Present Source: Modified from Mugo and Tweedle, (1999)

Species name	**River Nzoia**	**River Awach-Ahero**	**River Nyando**	**River Sondu/ Miriu**	**River Awach-Kendu Bay**
Synodontis victoriae		p			p
Pseudocrenilabrus multicolor	p	p		p	
Chiloglanis cf. somereni	p				
Aethiomastacembelus frenatus			p		
Amphilius cf. jacksonii	p				
Aplocheilichthys bukobanus			p		
Barbus altianalis	p	p	p	p	
Barbus apleurogramma	p		p	p	
Barbus cercops	p		p	p	
Barbus jacksonii	p	p	p	p	
Barbus kerstenii	p		p	p	
Barbus neumayeri	p		p	p	
Barbus nyanzae	p		p		
Barbus paludinosus	p		p	p	
Barbus yongei			p	p	
Brycinus jacksonii		p			
Brycinus sadleri		p			p
Clarias alluaudi			p	p	
Clarias gariepinus	p	p	p	p	p
Clarias werneri			p	p	
Ctenopoma murie			p		
Gambusia affinis				p	
Gnathonemus longibarbis					p
Hippopotamyrus grahami					p
Labeo victorianus	p		p	p	p
Leptoglanis sp.	p				
Marcusenius victoriae			p	p	p
Mormyrus kannume		p			p
Pollimyrus nigricans					p
Protopterus aethiopicus		p	p		
Schilbe intermedius	p	p	p		p
Synodontis afrofischeri				p	p

Table 7.3 Fish species of the satellite lakes and dams

Family	Species	Distribution
PROTOPTERIDAE	*Protopterus aethiopicus*	All lakes, dams
MORMYRIDAE	*Gnathonemus longibarbis*	LS
	Mormyrus kannume	LS,
CYPRINIDAE	*Barbus altianalis*	LK, LN, LS
	Barbus apleurogramma	Dams, LK
	Barbus cercops	Dams
	Barbus jacksonii	Dams
	Barbus kerstenii	Dams
	Barbus magdalenae	Dams
	Barbus neumayeri	Dams
	Barbus paludinosus	Dams
	Barbus radiatus	Dams
	Labeo victorianus	LS
CHARACIDAE	*Brycinus jacksonii*	Nyamboyo, Sare
	Brycinus sadleri	Sare,
MOCHOKIDAE	*Synodontis afrofischeri*	LS
	Synodontis victoriae	LS
CYPRINODONTIDAE	*Aplocheilichthys pumilus*	Dams LK, LN
	Aplocheilichthys	Dams
	Nothobranchius sp.	Ponds
CENTROPOMIDAE	*Lates niloticus*	LS
CICHLIDAE	*Oreochromis variabilis*	Mauna dam
	Oreochromis esculentus	LK,LN,LS,SD
	Oreochromis leucostictus	LN, Dams
	Oreochromis niloticus	LK, LS, LN and Dams
	Tilapia zillii	LS
	Astatotilapia nubila	Dams and all lakes
	Astatoreochromis alluaudi	LK, LS,LN, Dams
	Lipochromis maxillaris (Endemic)	LK
	Xystichromis phytophagus	LK, LS, LN, Futro dam
	Pseudocrenilabrus multicolor	LS, LK, Dams
ANABANTIDAE	*Ctenopoma muriei*	Floodplains, swamp
CLARIIDAE	*Clarias gariepinus*	LK, LS, LN, Dams

LK=Lake Kanyaboli; LS=Lake Sare, LN=Lake Namboyo

For example, as shown in Table 7.3, dams in the southern and northern portions of the Kenyan watershed of Lake Victoria host what could be the purest extant populations of *O. variabilis* and *O. esculentus* respectively. Pure strains of the two native tilapines are no longer found in Lake Victoria (Ojwang, 2006). Lake Kanyaboli is also the only water body known to have the endemic and endangered paedophagous haplochromine *Lipochromis maxillaris*. The SWB bodies are also home to several small Barbus species and other stress tolerant species such as *C. gariepinus* and *P. aethiopicus*. Surveys by Ojwang *et al*. (2007) in the SWB on the Kenyan side of Lake Victoria revealed a total of nine species of Barbus that included, *B. apleurogramma*, *B. cercops*, *B. neumayeri*, *B. kerstenii*, *B. paludinosus*, *B. jacksonii*, *B. altianalis*, *B. nyanzae* and *B. yongei* (Table 7.2).

Swampy areas, particularly the remaining wetlands along the shores of Lake Victoria, are also recognized as refugia to some of the native fish populations. Most of the fish species inhabiting the swampy areas are tolerant of extreme environmental conditions (Chapman *et al*., 2002). For example, *Protopterus aethiopicus* and *Clarias gariepinus* are physiologically hardy and have structures that enable them access to free atmospheric oxygen (Burgess, 1989; Witte and de Winter, 1995).

7.5 Rivers

The rivers draining Lake Victoria are a portion of the aquascape within the watershed-lake linkage that has also contributed significantly to the diversification and survival of many indigenous fish species. Most of the fish species in Lake Victoria, particularly the haplochromine cichlids, are thought to have evolutionarily originated from a riverine ancestor, with the rivers playing a key role as dispersal corridors. Studies by Ojwang *et al*. (2007), reported considerable numbers of *B. altianalis* and *L. victorianus*, an indication of recent reemergence and resiliency on the part of these fishes that if well nurtured could contribute substantially to the recovery of the original riverine fish assemblage of Lake Victoria. It is also evident from the study that the most important rheophilic species are now mostly confined to particular sections of the rivers. The near disappearance from the lake proper is mostly attributable to environmental conditions in the lake, use of wrong fishing methods and predation. The restoration of the historic riverine assemblage might not be far fetched if recent environmental mitigation activities, such as the ongoing reforestation, environmental impact assessment on all economic activities within the watershed, and ban of fishing along river mouths, are all strictly adhered to.

7.6 Current research and conservation activities

There are hardly any ongoing studies focusing on fish diversity and conservation in the Lake Victoria Basin. KMFRI initiated schools based program with the intention of creating awareness to both students and teachers. A survey was undertaken to assess levels of environmental awareness in pilot schools. The study noted serious lack of awareness and currently concerted efforts are in place to raise funds to involve more schools (both near shore and away from the lake) in the study and repackage necessary environmental information to empower teachers appropriately to abate the current wanton destruction of the lakes environment.

On another front, there are arrangements to ship a special exhibit on Lake Victoria back to Kenya and Uganda from USA. The exhibit "Nyanja-the African Inland Sea" is intended to educate and enlighten the local communities on the need to protect and conserve the lakes fauna and flora. The traveling exhibit which was developed with funding from the National Science Foundation has since moved from its 'original' home in Boston (New England Aquarium) to Duluth in Minnesota where sorting and repacking is ongoing ready for shipment to the lake region. KMFRI scientists in collaboration with Moi University scientists have proposed under LVEMP II to explore use of community protected sites in the lake Basin to augment the dwindling fisheries of Lake Victoria. This approach is intended not to alienate fishers but to involve them in the sustainable management of lakes resources.

The East Africa Barcode initiative in conjunction with the Consortium for the Barcode of Life (CBOL) facilitated a regional meeting where a proposal was developed to use DNA barcoding on cyprinids. This method is cost effective for biodiversity research as it hastens the process of species identification. The scope of objectives proposed include capacity building where several locals are envisaged to be trained in fish systematics and taxonomy.

7.7 Knowledge gaps

- Inadequate taxonomy of the fish species especially the haplochromines and cyprinids.
- Inadequate population genetics studies e.g. hybridization between the native and introduced tilapiines species and the genetic status of the surviving indigenous fish species.
- Lack of a centralized database for all the works done in the Basin.
- Poor state of data on the major rivers in the region.
- Lack of Catch Assessment data for satellite lakes.
- Inadequate involvement of relevant stakeholders in the conservation of fishery resources especially on the small waterbodies and floodplains.
- General lack of environmental awareness in the lake Basin.
- Potential impact of upstream migration of the piscivorous introduced Nile perch is unknown.

7.8 What needs to be done

- While there are adequate measures to control the fishery exploitation in the main lake, proper regulation measures aimed at controlling the fishing level and exploitation patterns in the satellite lakes especially Kanyaboli and Sare are not in place. Besides no catch statistics are being taken regularly. These need to be implemented given the importance of these water bodies to the livelihoods of the local communities.

- Several institutions have collected ad hoc fisheries data within the Basin and it is prudent that a framework be put in place to facilitate the establishment of a common Fishery database for the region for management purposes and to avoid duplicity of research.
- Establishment of research monitoring and data acquisition processes to ensure that the species composition, abundance, biodiversity, ecology etc are updated at appropriate intervals.
- Identification and involvement of relevant stakeholders in the conservation and management of the fisheries.
- Training in fish systematics and taxonomy.
- Establishment of Lake Basin based curated fish museum collections for education and research.
- Comprehensive surveys in small water bodies and rivers.
- Mapping and protecting already identified key habitats for sustainable exploitation.
- Concerted efforts to create environmental awareness in the Lake Victoria region.
- Enforcing already existing fisheries laws. Currently the law enforcers are poorly remunerated which is the basis of the level of poor governance witnessed in the sector.

7.9 Recommendations

1. Continue to promote the restoration of the historic fish assemblage;

2. Enhance the environmental mitigation activities such as the ongoing reforestation of degraded ecosystems, enforcement of environmental legislation paying particular attention to Environmental Assessments – Environment Impact Assessment and Environment Audits and where appropriate Strategic Environment Assessments;

3. Document success stories such as the re-emergence patterns of fishes in the different aquatic compartments of the Lake Victoria Basin;

4. Creation of environmental protection awareness for proper management of Lake Victoria to policy makers, the public and the private sector including the civil society;

5. Designating key habitats such as Lake Kanyaboli, Lake Nyamboyo, Lake Sare and Mauna Dam as protected areas and revamping policing of the lake resources by law enforcers.

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Fish Biology Experts

Dr. W. Oweke Ojwang (Kenya Marine & Fisheries Research Institute, Kisumu)
Andrew Asila (Kenya Marine & Fisheries Research Institute, Kisumu)
Daniel O. Okeyo (University of Fort Hare, Private Bag X1314, Alice, 5700, South Africa)
Dorothy Nyingi (National Museums of Kenya, Nairobi)

CHAPTER 8: AMPHIBIANS AND REPTILES

Mr. Malonza, National Musuems of Kenya

8.1 Introduction

The need to conserve species and their habitats is now more urgent than before as threats to biodiversity increase and have become widely recognized in the tropics. Wetlands and forests habitats like those within the Kenyan Nile Basin are some of the most affected. Some of these include the Kakamega forest which is the eastern-most remnant of the Guineo-Congolian forest, Nandi Hills forests, Mau Hills forest complex, Mt. Elgon, Cherangani Hills, Mara, Lake Victoria Basin including the Yala Swamp. All these are now categorized as important biodiversity areas of Kenya. Despite Kenyan Nile Basin diverse habitats and species diversity, its amphibian and reptile fauna remain relatively unknown. There are about 39 amphibian and 100 reptile species with low endemism. Herpetological studies in the region like in many other parts of Africa began in the colonial era that were mainly concerned with taxonomic descriptions leading to production of species lists (Loveridge, 1932; 1957; Duff-Mackay, 1980). From this early and recent collection, species guides have been produced (e.g. Spawls *et al.* (2002) on reptiles and Channing and Howell (2006) on amphibians. In this chapter the approximate number of currently known amphibian and reptile species in the Nile Basin Kenya are presented (see appendix 1) while highlighting recent species developments and threats. Provided also are the species conservation gaps for future work. Published species lists, unpublished data from taxonomic experts as well as the National Museums of Kenya (NMK) herpetology collection database were used.

8.2 Species present

In the context of this chapter all the species from the areas that are within and form the catchments of major rivers that drain into Lake Victoria such as Nzoia, Yala, Sondu-Miriu, Mara and Nyando were examined. These areas included but not restricted to Cherangani Hills, Kakamega forest, Nandi Hills, Mau Hills, Mt. Elgon, Uasin Gishu plateau and the Lake Victoria lowlands. In general very little species inventory has been done in most of these areas. What exists is from anecdotal species collection with no information on conservation status. Therefore, there are in total about 39 amphibian species and 100 reptile species in the region with very low endemism. All these species are indigenous with no known exotics or invasives. All amphibians in this region are mainly wetland inhabitants while a substantial number of reptiles are associated with wetlands and actually majority use wetlands as dry season refuge sites. However, some sites have received more attention in the recent years. A notable case is the Kakamega forest (see e.g. Bwong *et al*., 2005; Schick *et al*., 2005; Köhler *et al*., 2006; Lötters *et al*., 2006; Lötters *et al*., 2007). From these studies in this forest, about 40 species of snakes, 23 species of amphibians, 23 species of lizards and 1 species of terrapin have been recorded. Apart from Kakamega forest most of the other areas are largely unexplored. However, recent short collections have been done in Mt. Elgon and Cherangani Hills. Earlier in the 1980s Nandi Hills received some collection. In the other areas including the Mau Hills forest complex, Mara and the Lake Victoria Basin what is known is from early anecdotal collection. Otherwise apart from Kakamega forest no species checklists occur for these other areas in this region. Despite these minimal collection new species, e.g. Mackay tree frog *Leptopelis Mackayii* (Köhler *et al*., 2006) from Kakamega forest and Finch's rock Agama *Agama finchi* (see Böhme *et al.,* 2005) from Malaba have been discovered. In addition new species records are still being discovered (see Lötters *et al*., 2007) on Kakamega forest herpetofauna. However, there is no ongoing species target research works in the region.

8.3 Species distribution pattern and biogeographical affinities

Geographical patterns in species richness have fascinated biologists for decades and their causes have been the focus of many different disciplines especially community ecology. This results to non-random or patchy distribution of species. The question has then been to examine the underlying factors for this widely observed pattern (Navas, 2003). The species within the Kenyan Nile Basin consists of widespread as well as those restricted to certain biogeographical zones. More impotant is that the different sites share many species e.g. Kakamega forest with Nandi forests and Mt. Elgon. However, the region as a whole (normally referred to as the western highlands of Kenya) shares a number of species with the central highlands of Kenya (see Lötters *et al*., 2006). More important is the high species affinity of these western highlands forests e.g. Kakamega with the Guinea-Congo Basin forests (Schick *et al*., 2005).

8.4 Species threats and conservation status

Like with other biodiversity the species in this region face the overwhelming threat of anthropogenic habitat alteration. While this applies mostly to species outside protected areas, those within the protected areas (e.g. Kakamega forest) especially the reptiles face an additional problem of exploitation for pet trade. These combined threats earlier led to the protection by listing a number of these near-endemic amphibians (*Hyperolius lateralis*, *Leptopelis modestus* now *mackayi*) and reptiles (*Varanus niloticus, Atheris hispida, A. squamiger, Bitis gabonica, B. nasicornis, Causus lichtensteinii, Boiga blandigii, Boiga* *puvurulenta, Hapsidophrys lineata, Harmonotus modestus, Philothamnus heterodermus carinatus, Polemon christyi, Thrasops aethiopissa elgonensis, Pseudohaje goldi* and *Python sebae*, in the Wildlife (Conservation and Management) Act Cap 376 of 1981. This listing is now in the process of being revised to cater for new species and especially threatened Kenyan endemics. Again despite its existence it has not been effective due to relaxed enforcement. In general the conservation status of most of the reptiles and amphibians and especially the rare ones is unknown. Some species like the frog *Arthroleptides dutoiti* known only from Mt. Elgon is known from the type material collected in the 1930s.

8.5 Knowledge gaps

The status of amphibians and reptiles has not been investigated in detail, yet they may be seriously threatened by ecological changes that have taken place in the Lake Victoria Basin. Moreover, the impact of deteriorating water quality and habitat modification on amphibians and reptiles is inadequately known and should be investigated.

8.6 Recommendations

1. Promote research in the other areas besides the Kakamega forest and establish species lists of the other ecosystems in the region;

2. Undertake studies urgently to establish the conservation status of most of the rare and threatened species and their habitats especially in the fragmented Mau Hills forest complex to determine the impact of the forest loss and fragmentation on its herpetofauna.

3. Evaluate and document the impact of various human activities on reptiles and amphibians in the degraded ecosystems.

4. Undertake biogeographical studies in the region to establish herpetofuanal similarities and use information in the formulation of effective policy and management strategies.

5. Future conservation efforts should encourage all local activities and initiatives that preserve indigenous wetlands and forests.

6. All existing indigenous forest fragments should be accorded highest conservation priority.

7. Promote conservation efforts that link or buffer small indigenous forest fragments and/or wetlands through reforestation programmes.

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Kenyan Herpetologists

Patrick K. Malonza
Damaris Rotich
Victor D. Wasonga
Beryl A. Bwong

Vincent Muchai
Joash Nyamache

CHAPTER 9: BIRDS

Mr. Henry Ndithia, National Museums of Kenya

9.1 Introduction

The wetland habitats in the Lake Victoria drainage Basin are refuge for varied biodiversity, both flora and fauna. Among the animal components in these wetlands are the wetland birds also known as waterfowls. Waterbirds are birds that are ecologically dependent on wetlands, marine or fresh water habitats. There are 878 waterbird species Worldwide grouped into 33 major families. In Kenya there are more than 150 waterbird species.This chapter documents the areas waterbird researches have been conducted; waterbird species recorded in the Lake Victoria wetlands and its catchment areas; identifies the gaps in research which require to be addressed; and recommend the way forward in the conservation of the wetland ecosystems and waterbird species.

9.2 The Nile Basin Kenya

The catchment Basin of Lake Victoria and its wetlands (Figure 8.1), comprising of forest ecosystems, are a very important component of the entire Nile Basin. Some of these catchment areas, Mt. Elgon, Mau Forest Complex and Cherangani Hills, have been described as ‘water towers’ in Kenya together with Mt. Kenya and Aberdares ranges (Musila *et al*., 2005) because they are sources of large quantities of water used in Kenya. Other catchment areas include Lembus forest, Nandi Escarpment, Esoit Olool Escarpment and Elgeyo Marakwet escarpment forests. Mt. Elgon, Mau Forest Complex, North and South Nandi forests, Kakamega and Cherangani Hills have also been identified as Important Bird Areas (IBAs). IBAs are sites recognized internationally for conservation of wild birds.

Sites qualify on the basis of having globally-threatened bird species, range-restricted bird species─these are species whose total distributional area on earth is at most 50,000 Km^2 (Fishpool and Evans, 2001; Stattersfield, *et al*., 1998), biome-restricted species (bird species confined to a particular habitat type) or a site with large group of waterbird species at any given time (Fishpool and Evans, 2001; Bennun and Njoroge, 1999). Figure 9.1 shows the major catchment Basin for the Nile Basin while Table 9.1 shows details of rivers originating from these sites and the conservation issues of catchment areas that provide water to Lake Victoria.

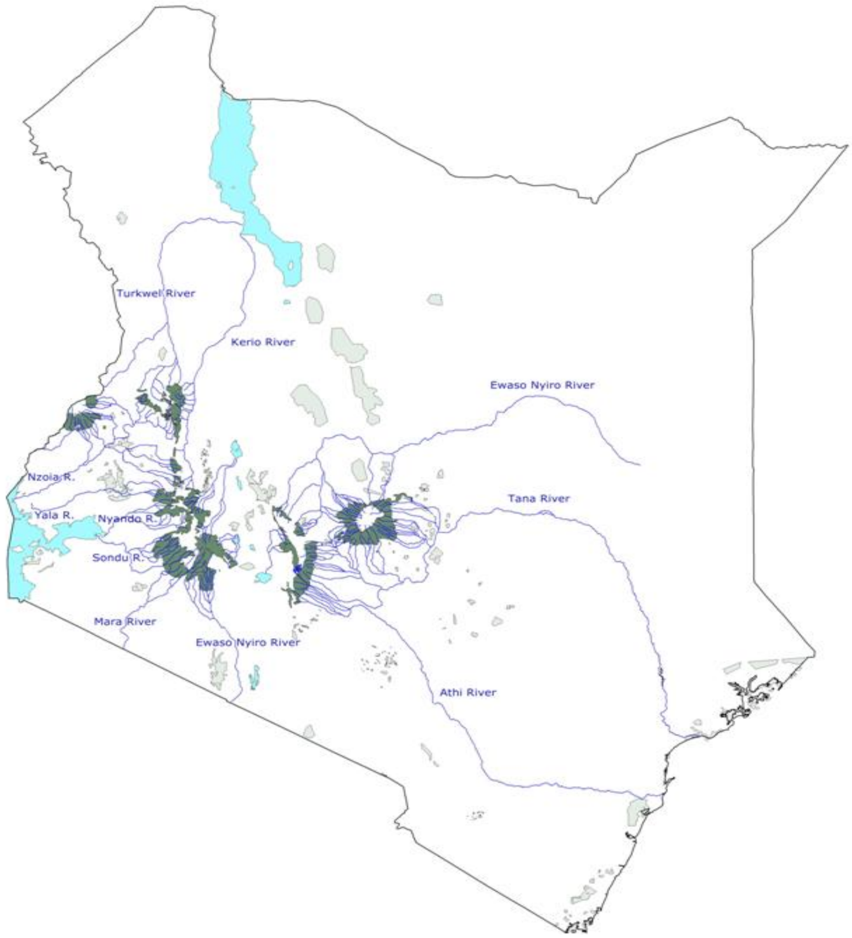

Figure 9.1 Major catchment region of the Nile Basin in Kenya. Map courtesy of UNEP/KWS.

9.3 The wetland areas fringing Lake Victoria shores in Kenya

Lake Victoria Basin has a fringe of papyrus *Cyperus papyrus* habitat around it which provides a number of environmental and ecosystem services that are habitats to very unique bird species. Some of the papyrus fringes are under consistent pressure and have been cleared in some areas over the years, even though some remain in a few wetlands around it. The wetlands have been identified as Important Bird Areas by Bennun and Njoroge, (1999). Some major notable wetlands/swamps and their conservation importance and threats are found in Table 9.1. These wetlands can be grouped into two depending on their distance from the lake: those swamps and marshes located in the Lake Victoria catchment Basin but far from the lake; those swamps located in the littoral zone of the lake. These two can further be classified into three categories depending on their water sources: riverine wetlands, inland delta wetlands, and freshwater swamps.

9.4 Wetland bird research surveys in Nile Basin Kenya

Research on wetland attributes such as vegetation, water quality, fish and aquatic invertebrates, among others, has been done extensively especially in wetlands fringing Lake Victoria. Some wetlands which have been covered include Yala, Koguta, Kusa, Dunga swamps and majority of other wetlands around the lake (Bennun and Njoroge, 1999; Nasirwa and Njoroge, 1997; Owino and Ryan, 2005; Kairu, 2001). In terms of waterbird research, little if any detailed ecological studies in Lake Victoria wetlands and catchment areas in the Kenyan sector have been done, save for the inconsistent waterfowl monitoring which commenced in 1995 (Waterbird monitoring Database, 1991-2007). However, some studies have investigated wetland habitats in close proximity to Lake Victoria and with bias to avian species of the Papyrus especially the papyrus endemic birds (Owino and Ryan, 2006; Bennun and Njoroge, 1999; Nasirwa and Njoroge, 1997; Maclean, *et al*., 2003). Studies were also carried out by Bennun and Njoroge, 1999 in the development of certain areas as areas of importance in bird conservation (Table 9.2).

Much of the information on wetland birds in the Kenyan sector of the Nile Basin wetlands has been recorded through the annual waterbird monitoring census. The waterbird census is an international monitoring strategy for wetlands biodiversity, which has been ongoing in Kenya since 1991 (Wambugu, *et al*., 2007). The initiative is part of the International Waterfowl Census (IWC) and regional African Waterfowl Census (AFWC) in Africa, both coordinated by Wetland International (WI) (Wambugu, *et al*., 2007). In Kenya, waterbird census is conducted mainly at Ramsar sites and other major wetland sites in January and July annually. Waterbird census started in Lake Victoria wetlands in 1995 (Waterbird monitoring database, 1991-2007). These counts have been done between January-February annually but inconsistently at all sites initially covered in 1995. The counts are carried out by volunteer amateurs and professional birdwatchers recruited from tour companies, members of Nature Kenya (the BirdLife International partner in Kenya); staff, interns and associates of Ornithology section of National Museums of Kenya; staff of Kenya Wildlife Service and members of Lake Victoria Sunset Birders (LVSB), a Community Based-Organization based at Dunga Beach, Kisumu. This comprises a team of competent volunteer bird counters using relevant equipment and standard data collection methodology. . Detailed methods and information on general organization are reported elsewhere by Bennun, (1992). Table 9.3 shows that a total of fourteen sites have been surveyed for waterbird species since 1995 with only eight sites covered in 1995. Sites covered have reduced over the years since the 1995 survey.

Dunga Beach has relatively been well surveyed except for 1996-7 and 2003. This is because members of Lake Victoria Sunset Birders, which has been actively involved in the monitoring, operates from Dunga Beach. No counts were conducted in any of the listed sites between 1996-7, and in 2003 due to financial constraints. Waterbird coordination requires huge funding for all wetland sites to be covered. Due to lack of solid funding, money for this activity has to be raised every time. Such funding strategy is not sustainable and has always been a challenge since the cost of the activity is not normally factored into the annual budgets of partner institutions involved in the exercise–Government institutions, international and national and community-based organizations.

Table 9.1 Forest areas which form the catchment Basin of Lake Victoria in Kenya, their conservation issues and specific rivers draining into the lake. IBA stands for Important Bird Areas or Important Biodiversity Areas

Forest Area	Status (bird conservation)	Rivers emanating to Lake Victoria	Conservation issues that may threaten river catchment
Mau forest complex (Western, South-Western and Eastern Mau Forests)	IBA	Nyando, Sondu Sandul, Kipsonol (joins river Kuja to form river Gucha then to the lake Kipsonol)	Pressure on productive land by the Ogiek people, loss of forest (28% in 12 years) through excision, unregulated immigration of ethnic groups to the forest, grazing, roads construction.
Mt. Elgon Forest	IBA	Ikuywa, Nzoia, Koitobos, Malakisi (Uganda), Kelim (Uganda),	Illegal timber extraction, commercial logging, fires. Has many attractions (moorland, peaks, caves, birds). Need an integrated management plan.
Cherangani Hills	IBA	A tributary (source) of Nzoia	Human encroachment, de-gazettement of forest for settlement, tree poaching, livestock grazing, tree felling for honey, occasional fires, farming. Tremendous potential for eco-tourism due to cascading rivers.
Kakamega Forest	IBA	A tributary of Nzoia	Logging for commercially valuable timbers, conversion to plantation, excision for settlement, illegal felling, forest fragmentation, human pressure, revisit conservation plan for the forest.
North Nandi Hill Forest	IBA	Yala	Have many birds with very limited ranges, plans to convert forest to plantation, pressure from illegal timber extraction, charcoal burning, forest grazing, unsustainable removal of forest products, no clear boundaries and special protection, forest a very narrow strip.
South Nandi Hill Forest		Yala	Most threatened IBAs in Kenya, under pressure from growing human population, several large excisions, and conversion of indigenous forest to Nyayo tea zone, illegal encroachment. There is failure to appreciate the biodiversity conservation and water catchment importance of this forest.
Elgeyo Marakwet Escarpment	Non-IBA	Sergoit – joins Nzoia, several tributaries of Nzoia	Study needed to establish the status
Lembus Forest	Non-IBA	A tributary of Nzoia	Study needed to establish the status
Trans-mara Forest	Non-IBA	Kipsonol – flows into riverKuya and joins river Gucha	Study needed to establish the status
Esoit Oloolol Escarpment	Non-IBA	Migori	Study needed to establish the status
Nandi Escarpment	Non-IBA	A tributary of Nzoia	Study needed to establish the status

Source: Bennun and Njoroge, (1999); Kenya Tourist Board, (2000).

Table.9.2 Important Bird Area sites in the Nile Basin, their status and bird conservation importance and threats

IBA Site	Site Status and Area	Key bird species	Bird status	Conservation issues	Notes and comments
Dunga Swamp	Unprotected, area 500ha	Papyrus Yellow Warbler	Globally-threatened (Vulnerable)	Sewage solid waste from Kisumu town, excessive and unsustainable papyrus harvesting, Water Hyacinth-related problems. Require better formal protection (no conservation status at present.	Most reliable for Papyrus Yellow Warbler. All but one Lake Victoria biome species found here.
		Papyrus Gonolek	Globally-threatened (Near-threatened)		
Koguta Swamp	Unprotected, public land area 1800ha	Papyrus Yellow Warbler	Globally-threatened (Vulnerable)	Water Hyacinth-related problem on fishing. Excessive and unsustainable papyrus harvesting, overgrazing by cattle in dry spell. Formal protection/ community conservation programme (sustainable use of wetland).	Home of Papyrus Yellow Warbler. Six Lake Victoria biome species found here.
		Papyrus Gonolek	Globally-threatened (Near-threatened)		
Kusa Swamp	Unprotected, public land area 1000ha	Papyrus Gonolek	Globally-threatened (Near-threatened)	Uncontrolled cutting of Papyrus by locals. Pollution and siltation from Nyando river.Rice farming by local resident.	Has substantial stand of Papyrus. Papyrus Gonolek fairly abundant here. Four Lake Victoria biome species found here.
Yala Swamp Complex	Unprotected, area 8000ha	Papyrus Gonolek	Globally-threatened (Near-threatened)	Reclamation of the Swamp for agriculture for dense population. Irrigation water uptake, Intensification of fertiliser and biocide input, Unsustainable exploitation of Papyrus for the mat-making industry. Extensive burning to open up area for agriculture.	Important site for protecting the increasingly threatened suite of Papyrus birds. Rehabilitation of feeder canal to Lake Kanyaboli high priority─lack of regular inflow from Yala river changing its water chemistry and may interfere with its function as a fish refuge and nursery.
		Papyrus Yellow Warbler	Globally-threatened (Vulnerable)		
		Great Egret	Regionally-threatened (Vulnerable)		
		Baillon's Crake	Regionally-threatened (Vulnerable)		
Sio Port Swamp	Unprotected, area. 400ha	Papyrus Gonolek	Globally-threatened (Near-threatened)	Increasingly threatened by unsustainable use. In urgent need of better protection. Infestation by Water Hyacinth, building pressure on alternative-wetlands utilization.Large-scale clearing for cultivation, rice.	Further survey needed to establish whether the threatened Papyrus Yellow Warbler is present, and if so, at what densities.Important for 7 Lake Victoria biome species especially 3 Papyrus endemics: Papyrus Gonolek, White-winged Warbler and Papyrus Canary.

Source: Bennun and Njoroge, (1999); Musila, *et al*., (2005); Ngw'eno *et al*., (2004); Munyekenye, *et al*., (2007)

9.5 *Waterbird species in wetland sites surveyed*

About 82 different wetland bird species have been recorded in the 14 different sites surveyed. This included 45 resident bird species known to remain within Kenya, 12 Afro-tropical migrant bird species which migrate within the African continent and 25 Palaearctic migrant bird species wintering in Africa from Europe and Asia continents and Russian. Long-tailed Cormorant *Phalacrocorax africanus* had the highest estimate of 8481 bird individuals. Details of the individual totals of all wetland bird species recorded between 1995-2007 in the 14 wetland sites surveyed are in Appendix 2.

Table 9.3 Sites around Lake Victoria where waterfowl monitoring has been undertaken since 1995

No.	Wetland Surveyed/Year	'95	'98	'99	'00	'01	'02	'04	'05	'06	'07
1	Dunga Beach	*	*	*	*	*	*	*	*	*	*
2	Kano Plains	*									
3	Tako River	*									
4	Rota Beach	*									
5	Sondu-Miri River Mouth	*	*	*	*	*	*				
6	Got-Kachola	*									
7	Lake Simbi	*						*			*
8	Pengle	*									
9	Nyamwere Rice Fields		*	*	*	*	*	*			
10	Obange Pond			*							
11	Kisumu Sewage Ponds					*			*	*	*
12	Sangorota							*			
13	Yala Swamp							*	*	*	
14	Rusinga Island									*	
Total Sites Covered		8	2	4	3	4	3	5	5	3	3

Source: Waterbird Monitoring database, 1991-2007. * indicate census done

Table 9.4 Total numbers of waterbird individuals and species recorded in Dunga Swamp IBA since 1995. No counts were done at the site between 1996-7 and 2003.

Year	Total Species recorded	Waterbird Totals
1995	28	632
1998	62	188
1999	26	543
2000	31	468
2001	11	272
2002	27	788
2004	22	269
2005	19	195
2006	33	369
2007	24	231

The value of any monitoring programme lies in the regular collection of data in a systematic manner. Monitoring data becomes increasingly valuable as the time series becomes longer. A break in the series substantially reduces the value of the information. However, waterbird counts have taken place in Dunga Beach IBA for nine years, although inconsistently (Table 9.4) and is the only site which has been counted relatively consistently among the 14 sites. Dunga swamp reflects fluctuating trends in waterbird numbers with a general decline from 2002 through 2007 (Figure 9.2), although a consistent set of data would reveal a better picture of waterbird populations of a site. This trend is reflected by the other sites, especially Sondu-Miriu and Nyamwere rice fields.

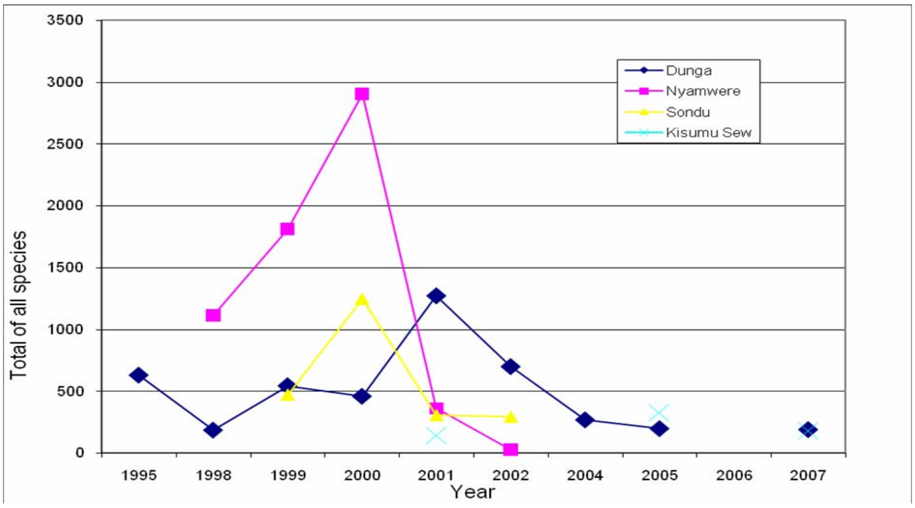

Figure 9.2 Trends in total waterbirds in four sites of Lake Victoria wetlands, 1995-2007. Source: Waterbird Monitoring database, 1991-2007.

9.6 *Wetland birds conservation interventions*

There is need to conduct a more thorough study. Surveys conducted here are not specific to riparian areas of permanent rivers but biased to the terrestrial ecosystem. Waterbird surveys in all swamps around Lake Victoria and the islands in it as well as the riparian habitat of the permanent rivers which drain into the lake are necessary. This is vital so that the current status of wetland birds in the Lake Victoria region of Kenya can be effectively understood in order to draw up effective conservation interventions. Such surveys can help identify sites most important for conservation of waterbird species in terms of diversity, abundance, national and international consideration especially for the endangered species. This information is important since it can be used to increase awareness to visitors and promote tourism in the region. Detailed ecological studies targeting particular waterbird species in relation to their habitat requirements are required (eg Papyrus endemics, Papyrus dependent, etc.). Strengthening the capacity of the members of CBOs, local people and other institutions to get involved in the annual waterbird monitoring scheme currently being conducted in few sites around Lake Victoria, and to participate in general applied research on birds and their habitats. This is quite important such that data on waterbird numbers and species can be consistently generated over the years and hence be in a position to link trends with habitats conditions. A sustainable funding for waterbird monitoring activities will ensure that there are no breaks in the monitoring efforts and therefore derives more value from monitoring data.

9.7 Knowledge gaps

There has been limited waterbird ecological research conducted both in the proximity of Lake Victoria, along the permanent rivers and the associated riparian habitats except for only the annual waterbird monitoring scheme which has covered a total of 14 sites inconsistently since 1995. The limited information on rapid and detailed ecological surveys on wetland birds and their habitat in the entire catchment area is an indication of the need to learn more from this group of species and their current status, with studies of individual species and functional groups of birds.

9.8 Recommendations

1. There is need for research to establish the impact of changing fisheries and habitats on avian biodiversity.

2. It is also necessary to carry out a Basin-wide study of the movement and settlement patterns of migratory birds that winter in Lake Victoria Basin.

3. A study on avian biodiversity and the changing environment is necessary in order to plan for conservation and development of eco-tourism in the Lake Victoria Basin.

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CHAPTER 10: MAMMALS

Mr. Bernard R Agwanda,
Mammal Section, National Museums of Kenya.

10.1 Introduction

The importance of wetlands to mammals can be traced to their role in the evolutionary adaptations of divergent evolution of Elephants, Dugong and Manatee, Marsh mongoose and savannah Cane rats, Tragelaphin antelopes with sitatunga 'back in the swamp'. Wetlands also play *refugia* role in both the recent evolutionary adaptations for many species as well as seasonal backups. Species such as De Braza monkey (*Cercopithecus niglectus*) may have been forced to inhabit riparian forests due to stiff competitions from other primates and other animals in other habitats. From the 'ghost of competition past' theory (Begon *et al*., 1986), many other species are occupying niches (e.g. habitats) after being excluded elsewhere by competitors. There are many mongooses with closely contested niches. Marsh mongoose, for instance, may have been driven to swampy areas to survive. *Hippopotamus amphibious* may have escaped predators by going into water to rest.

Wetlands, however, are far more important than just being a home to aquatic mammals. They are *refugia* to many species during droughts besides daily water service. Unfortunately, wetlands are target to many conservation unfriendly activities. Activities such as agricultural expansions and settlement are the primary causes of destruction and fragmentation of wetland habitats and biodiversity. Fragmented habitats inhabited by mammals' populations then become either unviable and/or prone to stochastic events. Conservation of wetlands is, therefore, critical for both socio-economic development per se, but also for biodiversity management. In the absence of knowledge on aquatic mammals in wetlands of Nile Basin, both conservation motivations and management decisions remain void. As a first step towards ensuring effective and sustainable management of wetlands in the Nile Basin Kenya, it is important to have a brief overview of the existence, habitat and threats to some aquatic mammals within the Basin. Information gaps are highlighted to aid prioritizing future efforts.

10.2 Artiodactyla, even hooved mammals

10.2.1 Hippo, Hippopotamus amphibious

Eight species lived in Africa about one million years ago, four of these species lived in Lake Turkana Basin then, to date only two species exist in Africa, and out these two species only one species exists in Kenya (i.e. *Hippopotamus amphibious*). The reasons for extinction of the other six species are not very clear, but climate change and increased human activities are thought to be the contributors to the cause. Distribution range of the one species in Kenya is highly confined in Nile Basin, but also found all over the country. In the Nile Basin, River Yala, River Nzoia, the whole of Lake Victoria shoreline and Mara River have major populations of *Hippopotamus*

amphibious. The following are the food,ecological role, status and threats to this species:
Food: Lawn mower of tussock and creeping grass.
Ecological role: Limits fire incidences by removing grass layer.
Status: Quickly losing range and food.
Threats: Foraging areas are alarmingly converted to agricultural farms and human settlements; farming up to riverine, hunted for meat and due to conflict as a pest in the agricultural farms; water pollution (chemicals) suspected to affect under water suckling babies. Population densities unknown.

10.2.2 Sitatunga, Tragelaphus spekei spekei

This antelope is thought to have been excluded by its relatives from dry land and forced go to water where competition was not fierce. Two distinct but small populations records are recognized in Saiwa and Kingwal-Eldoret. Yala swamp and Nandi swamp populations are contained in informal records but scientifically unrecorded. Other informal records suggest that recent historical ranges covered Homa Bay areas, South Nandi areas, among other areas around Lake Victoria Basin and catchments of its rivers. The habitat, food, threats and status of this species are as follows:

Habitat and Food: Heterogenous swampy bushes (bushes, herbs and grasses) are preferred. However, homogenous/Monostands of specific vegetations are less preferred. The species feeds on wetland grasses, herbs and shrubs (Plate 10.1).

Heterogenous swampy bushes preferred by *Tragelaphus spekei spekei.*

Most of its current habitats have been interfered with due to increased human activities resulting to the species decline (Plate 10.2).

Human activities in current *Tragelaphus spekei spekei* habitat.

Threats: Farming encroachment destroys food resources and hunting for meat reduces the population. Population trends only known from Saiwa, others remain unknown.
Status: *Tragelaphus spekei spekei* is endangered in Kenya because of habitat loss and hunting.

10.3 Carnivora

10.3.1 Clawless otter, Aonyx capensis

This species has unwebbed feet prefers rivers and streams as its habitat. Kingdon (1997) contends it is widespread in East Africa. But the species was documented from rivers: Yala, Nzoia,and Mara (1975) expedition and National Museum of Kenya records). It is also found in Saiwa swamp. This species food include: mainly fresh water crabs, but also takes frogs, molluscs, birds and small mammals. The sharp decline of otter populations may be due to several factors including increased turbidity of water from increased soil erosions. However, sensitivity to water pollution especially through food chain is not known yet.

10.3.2 Spot-necked otter, *Lutra maculocollis*

It is recognized by body size of 4-7kg, half size of Clawless otter, *Aonyx capensis*, deep golden in colour, throat is white with spots. Its habitat is clear water in Lake Victoria and rarely inhabits rivers. The Spot-necked otter food is principally fish, but also frogs, aquatic inverterbrates and molluscs. The major threats include: soil erosion (turbidity) (Kingdon, 1997), fish nets and vandalism, destruction of shoreline-breeding/feeding ground. Populations are unknown and status unknown.

10.3.3 Marsh mongoose, *Atilax paludinosus*

This species is recognized by dark brown color of skin with shaggy oily fur; splayed hands.Its habitat is mainly swamps on rivers or Lake shores (reedbeds, swamp grasses or bushes). *Atilax paludinosus* food include: crabs, snails, frogs, catfish, lungfish, reptiles, rats/mice, birds, larvae of invertebrates. The species has lost ground in many ranges.

10.3.4 Giant Otter shrew, *Potamogale velox*

Recognition: - Smaller than otter, just a shrew, bicolored-brown back and white underside, improportionally large bladed tail, broad snout in thick bristles, nostril with disc-shields, swim like fish. Taxonomically special in Kenya, relative of Madagascar Tenecs. Its habitat and food are as follows:

Habitat: Only known from Yala and Nzoia River water in fast and slow waters but rest and breed in burrows in stable banks and beds.
Food: aquatic invertebrates, small fish, frogs, molluscs; nothing else known, other than records (Kingdon, 1971).

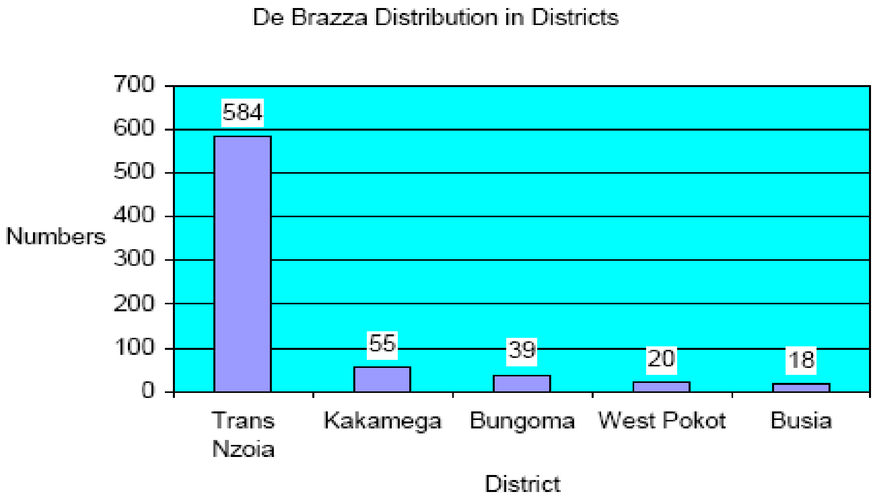

Figure 10.1. Distribution of De Braza monkey *Cercopithecus niglectus* in Western Province in Kenya.

10.3.5 De Braza monkey Cercopithecus niglectus

It depends on riparian galleries, in Kisere, and many private forests in Western Kenya. Never leaves river course more than 200 m. The food and status of this species are as follows:
Food: fruits and seeds, occasional leaves
Status: very rare and endangered, due to frequent conversion of its habitat to agriculture. Seed disperser to riparian fig trees and others (Figure 10.1). Other Mammals associated with Wetlands in Nile Basin are: - Marsh cane rat, *Thryonomys swinderianus;* Shaggy swamp rat, *Dasymys incomptus;* Creek rat, *Pelomys isseli;* Lophuromys spp., and Hammer headed bat (*Hypsignathus monstrosus*) which inhabit riverine trees and palm.

10.4 Knowledge gaps

There is no basic data on the ecology and populations of sitatunga, hippopotamus, and African otters in the Nile Kenya sub basins. Without baseline information on these animals, it is difficult to evaluate, monitor and even update the status of the biological integrity of the Lake. It would be necessary to undertake studies that can identify suitable bioindicator species so as to assess ecological changes resulting from environmental degradation (Gichuki, 2003)..

10.5 Recommendations

Most records on wetland mammals are based on 1970s observation. Thus, there is need to:

- re-affirm the records for most species;
- inventory mammal species; and
- monitor mammal populations' dynamics.

In addition, the impact of deteriorating water quality and habitat modification on wetland mammals is unknown and should be investigated.

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CHAPTER 11: SOCIO-ECONOMIC STATUS

Dr. Julius Manyala,
Moi University, Kenya

11.1 Introduction

The wetlands of the Nile Basin Kenya play an important role in the livelihood and subsistence economy of local communities. They are sources of fresh water, fish, medicinal plants, and vegetable species. They also support subsistence agriculture, as well as mining of sand and soil, which are used to make marketable products. Wetland vegetation, especially papyrus, grasses and water hyacinth provide materials for making mats, baskets, furniture and other marketable products (Katua and M'mayi, 2001). These economic activities contribute to poverty alleviation and job creation in rural areas. Wetland products and services, such as transport and tourism, have potential to contribute towards poverty alleviation in rural areas. However, socio-economic studies that could illustrate the significance of wetlands to alleviation of rural poverty in Lake Victoria Basin are scarce. Substantial information however, exists on the socio-economic impacts of the declining fisheries and liberalisation of fish trade on people's livelihood and economic status (O'Riordan, 1996). Wetlands provide an alternative resource base for supporting livelihood and generating income.

Currently, the Yala Swamp, Nyando and Sondu Swamps are being drained for agriculture. On the Kano Plains, about 900 hectares had been converted for rice and sugar cane production. The Government of Kenya carried out large scale reclamation of wetlands in the Lake Victoria Basin for agriculture with the objective of providing food security, poverty reduction and job creation. The implementing agency, Lake Basin Development Authority (LBDA) reclaimed 2,300 hectares of Yala swamp out of 17,500 hectares that make Yala swamp ecosystem. This was done to grow maize, coffee, oranges, millet, avocados, bananas and rice. However, the high production costs, poor crop prices and mismanagement of the scheme forced LBDA to abandon large chunks of reclaimed land in the 1990s. In March 2003, a rice and cotton scheme was started on the abandoned land by a United States based Company Dominion after an Environmental Impact Assessment (EIA) study was done and accepted by National Environment Management Authority. In 2005 another EIA was prepared for the expansion of the activities of the company. The scheme is expected to employ 500 people and produce 450,000 tons of rice annually (Chumo, 2003).

11.2 Population development

In the Kenya sector of Lake Victoria Basin the human population is approximately 12 million people. About 80% of the population live in rural areas while the rest (20%) live in urban centres. Between 1989 and 1999, the population living in riparian districts of the Lake Victoria Basin increased from 8.4 to 12.0 million. During the same period, the population living in urban areas sharply increased from 630,000 to 1,400,000. The rapid growth in urban population implies increased water consumption and waste generation. The population density in the basin is over 100 per square kilometer (Figure 11.1) and ranges between 220 and 1200 persons per square kilometer. The two figures are higher than an average of 174 persons per square kilometre in the whole of the basin. The population density in the Kenya part of the Lake Basin is much higher than the national average. The average population growth rate is 3.8% per year, which is also higher than the national average of 3.2% and the 3.0% average for the whole of Lakes Victoria Basin (Government of Kenya, 1987). Rapid population growth and its growing demand for resources, especially land, water and fisheries are increasing pressure on Lake Victoria and its environs. Increasing human population, poverty and significant migration of people from one part of the basin to another largely drives human-induced pressures. Increasing human pressure on Lake Victoria Basin has led to intensification of land use, overgrazing of pastures, drainage of wetlands, over fishing and general degradation of water and forest resources. The evidence for environmental degradation manifests itself in low agricultural production, low fish yields, lack of fuel wood, pollution of water resources and noticeable loss of biodiversity.

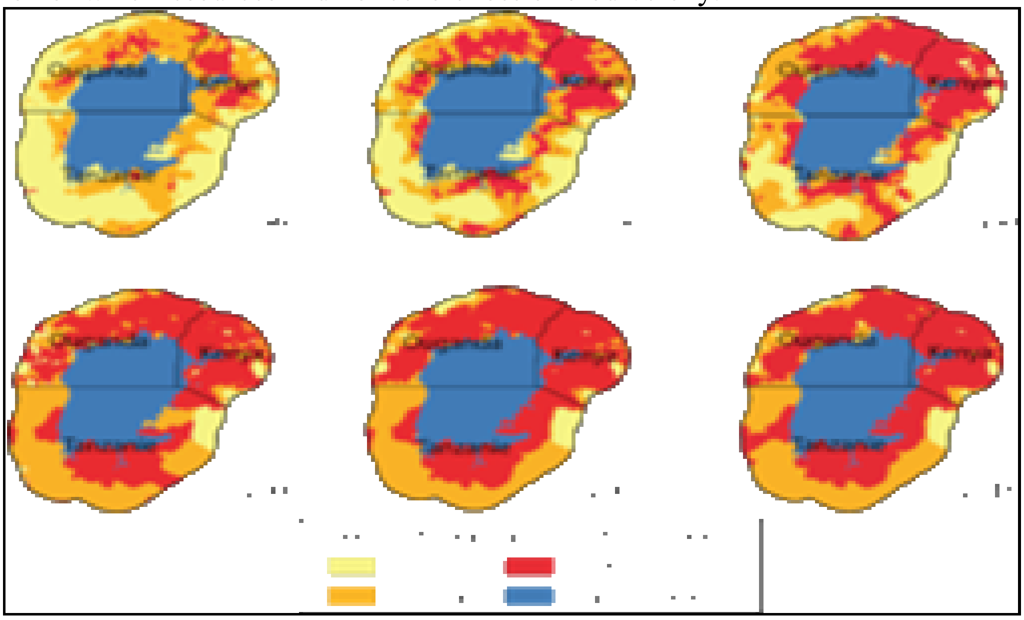

Figure 11.1. Density growth around Lake Victoria

11.3 Human Impact and Utilization

Both the Yala Swamp, and the Nyando and Sondu Swamps on the Kano Plains are continually being drained for agriculture. It had been estimated that at least 14 000 hectares (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 have so far been reclaimed in Yala Swamp in Siaya District.
A number of factors have contributed to the overall environmental conditions prevailing in the lake Basin wetlands. High population pressure has resulted into greater demand for land for settlement and agriculture. As a result of these the area is currently experiencing: severe soil erosion; siltation of major rivers and lakes; planting of unsuitable plant species in the wetland areas; clearing of vegetation and cultivation along river banks and lake shores; introduction of alien species; massive deforestation; reclamation of wetlands; over fishing in the lake waters; pollution of the water systems from agro-chemicals and urban effluents. Emerging scenarios include the wetland ecosystems claiming parts of available land and displacing community in the low-lying land areas, e.g., in Budalangi (Bunyala District). This perpetual annual disaster can be possibly attributed to poor land-use practices associated with population increase.

11.4 Wetland functions, values and uses

Wetlands in the Lake Victoria Basin provide the following goods and service: building materials, mats, fisheries resources, pollutant sinks, habitants for wildlife, recreational areas (sports/hunting/bird-watching), grazing and water supply.Given the socio-economic role of these wetlands in the region, their conservation is of great importance for sustainable development of the entire Lake Victoria Basin region. It is anticipated that the on going analysis of various data sets on a number of attributes will provide a base for determining the status of the environment in Lake Victoria. Wetlands have both direct and indirect (ecological) functions to the riparian communities. The wetlands are known to control flood waters i.e. storm abatement, they act as silt trap, water storage and release in dry seasons. They are also habitats for various wildlife like crocodiles, oaters, monkeys, hare, rabbits, snakes and some of the rare and endemic birds. This function is always underestimated for wetlands. The more obvious uses of wetlands however include grazing on the edges of wetlands, source of food and medicinal plants and provision of building for the local communities. The wetlands provide a source for domestic water supplies and livestock watering.

In recent times, the use of wetlands to extract clay for brick making has gained prominence in Western Kenya, but other uses like mat and craft making are widespread. In some rare occasions, wetland resources serve for both aesthetic and direct use such as the circumcision ceremonies where clay soils are smeared on the body. With the advent of severe encroachment in wetlands in Western Kenya, many *Eucalyptus* trees have found their way into several of these wetlands, with negative effect on other fauna and flora. Sand mining has become prominent in riverine/lacustrine wetland areas while traditional hunting of small game has slightly declined with more efforts being put on wildlife conservation by the Kenya Government. One of the most exploited faunas of the wetlands in the lower Basin is fish. There are communities living in wetland areas whose entire life revolves around fishing e.g. Yala Swamp Villages.

The threats to wetlands in Western Kenya were considered on the basis of the source in relation to the position of the wetland, i.e. lower and upper reaches and also on the basis of observed disturbances in the wetland. Most of the threats to wetlands in the Basin are in Western and Nyanza Provinces where some divisions had all their wetlands (100%) under different kinds of threat. On the overall, about 34% of all the wetlands in the region are under serious threat. The sources of threat to wetlands in Western Kenya range from demand of land for agricultural purposes to direct and unsustainable exploitation of the wetland resources, especially the macrophytes (see appendix 3). Threats from overexploitation of the macrophytes and reclamation for agriculture/horticulture seem to be the biggest sources of threats to these wetlands. These threats also seem to be more pronounced in Western and Nyanza Provinces as compared to Rift Valley (Appendix 4).

11.5 Knowledge gaps

The link between the productive activities of the local community and their impact on the ecological integrity and biodiversity of wetlands is completely lacking. There is need for research to link socio-economic activities with the ecological requirements that are necessary to maintain and in fact enhance resources that people derive from wetlands.

11.6 Recommendations

Fish farming is still poorly developed in Lake Victoria region. Research should be undertaken to improve management of fish farms with a view to improve fish production and hence ease fishing pressure on Lake Victoria.

Institutional collaboration for research and dissemination of information is weak. Collaboration between University and national research institutions should be promoted with a view to improving the quality of research, data analysis and publication of the results.

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APPENDICES

Appendix 1. Tentative distribution of amphibians and reptiles across the Kenyan Nile Basin. Threatened species are asterisked. Specific species record locality are given in parentheses. KK = Kakamega forest, NDI = Nandi Hills, LVB = Lake Victoria Basin, CHER = Cherangani Hills, Mau = Mau Hills forest complex and its environs, Mara = Kenya Mara ecosystem.

1. Amphibians (39): Xenopus victorianus (KK, LVA, NDI), Xenopus borealis (Mau, Mara) Amietophrynus kisoloensis (KK, Mau, NDI, CHER, LVB), Amietophrynus maculatus (KK, Mau, Mara, LVB), Amietophrynus gutturalis (Mau, LVB), Amietophrynus kerinyagae (Mau), Schismaderma carens (Mara), Phrynobatrachus mababiensis (KK, LVB), Phrynobatrchus keniensis (Mau,CHER), Phrynobatrchus natalensis (KK, LVB, Mau, Mara), Phrynobatrchus graueri (KK, NDI), Cacosternun boettgeri (Mau), Amietia angolensis (KK, Mau, Elgon, NDI), Amietia wittei (Elgon, CHER, Mara), Hydrophylax albolabris (KK, NDI, LVB), Hydrophylax galamensis (LVB), Ptychadena anchietae (KK, Mara, NDI, Mara, Mau, Elgon, LVB), Ptychadena mascareniensis (KK, Mau, CHER, Elgon, LVB), Ptychadena chrysogaster (LVB), Ptychadena oxyrhynchus (KK,), Ptychadena porosissima (KK, LVB), Ptychadena taenioscelis (KK), Ptychadena mahnerti (Mau), Hoplobatrachus occipitalis (KK, Mau, Mara, LVB), Arthroleptides dutoiti (Elgon), Afrixalus osorioi (KK), Afrixalus fulvovittatus (KK, NDI), Hyperolius acuticeps (KK, LVB), Hyperolius cinnamomeoventris (KK, NDI, Elgon), Hyperolius argentovittis (Elgon), Hyperolius montanus (Mau), Hyperolius kivuensis (KK, NDI, LVB), Hyperolius lateralis (KK, Elgon), Hyperolius viridiflavus (KK, Mara, NDI, Elgon, Mau, LVB), Kassina senegalensis (KK, LVB, Elgon, Mara), Leptopelis mackayi (KK), Leptopleis bocagii (KK), Chiromantis petersi (LVB), Hemisus marmoratus (LVB)

2. Reptiles (100): Lizards (42); Acanthocercus atricollis minutus (KK, NDI), Acanthocercus cyanogaster (NDI, LVB, Mau), Agama kaimosae (KK, NDI), Agama finchi (KK, LVB), Agama caudospinosa (Mau, NDI), Agama agama lionotus (NDI, Mara), Agama agama elgonensis (Elgon, CHER), Agama mwanzae (Mara), Latastia longicaudata (CHER), Chamaeleo gracillis (KK, LVB), Chamaeleo quilensis (LVB), Chamaeleo hoehnelli (KK, Mau, Elgon, NDI), Chamaeleo laevigatus (KK, LVB), Chamaeleo bitaeniatus (CHER), Chamaeleo (Trioceros) ellioti (KK, NDI, LVB, CHER), Rhampholeon boulengeri (KK, NDI), Cnemaspis(Ancylodactylus) elgonsis (KK, Elgon), Hemidactylus mabouia (KK, LVB, Elgon, CHER, Mau, LVB, NDI), Hemidactylus brookii (CHER), Hemidactylus squamulatus (Mara), Lygodactylus gutturalis (KK), Lygodactylus capensis (Mau), Eumecia anchietae (KK, Elgon, Mara, NDI), Feylinia currori (KK, LVB), Lygosoma fernandi (KK), Lygosoma sundevalli (LVB, Mau, Mara), Lygosoma sundevalli afrum (LVB), Panaspis wahlbergi (LVB), Gerrhosaurus nigrolineatus (Mau), Mabuya (Trachylepis) maculilabris (KK, LVB), Mabuya (Trachylepis) megalura (KK, Mau), Mabuya (Trachylepis) quiquetaeniata (KK, LVB), Mabuya (Trachylepis) striata (KK, NDI, CHER, Mau, Elgon, LVB, Mara), Mabuya (Trachylepis) irregularis (Elgon), Adolfus africanus (KK), Mabuya (Trachylepis) varia (LVB, Elgon), Adolfus alleni (Elgon), Adolfus jacksoni (KK, LVB, NDI, CHER, Elgon, Mau, Mara), Chameasaura (Cordylus) anguina tenuior (KK, Mau, CHER, NDI), Varanus niloticus (KK, NDI, LVB, Mau, Mara), Nucras boulengeri (Mara). Snakes (54); Letotyphlops scutifrons merkeri (Mau), Leptotyphlops macrops (LVB), Typhlops angolensis (KK), Rhinotyphlops lineolatus (KK, NDI, LVB), Rhinotyphlops brevis (LVB), Python sebae (LVB, Elgon), Crotaphopeltis hotamboeia (KK, LVB, NDI, Elgon, Mau,

Mara), Crotaphopeltis degeni (LVB, NDI), Dasypeltis atra (KK, NDI, Mau, Elgon), Dasypeltis scabra (KK, NDI,Mau, Elgon, CHER), Meizodon semiornatus (LVB), Dispholidus typus kivuensis (KK, NDI, Mara, Mau, LVB), Hapsidophrys lineatus* (KK), Lamprophis fuliginosus (KK, LVB, Elgon, CHER), Lamprophis olivaceaus (NDI), Lycophidion capense jacksoni (KK, Mau, Mara, Elgon, NDI), Lycophidion depressiorostre (KK, NDI), Lycophidion ornatum (KK, NDI), Mehelya capensis savorgnani (KK, NDI, Mau), Natriciteres olivaceae (KK, NDI, LVB, CHER), Duberria lutrix (LVB, Mau, NDI), Philothamnus battersbyi (KK, NDI, Mau,LVB, Elgon), Philothamnus carinatus* (KK, LVB), Philothamnus heterolepidotus (KK, LVB), Philothamnus hoplogaster (KK, Elgon), Philothamnus nitidus loveridgei (LVB, KK), Philothamnus semivariegatus (LVB), Psammophis mossambicus (KK, LVB), Psammophis phillipsi (KK), Psammophis rukwae (KK), Grayia tholloni (LVB), Psammophylax multisquamis (KK, Mau), Dromophis lineatus (LVB), Thrasops (Rhamnophis) aethiopissa elgonensis* (KK, Elgon), Thrasops jacksoni (KK, NDI, Mau, LVB), Boiga (Toxicodryas) pulverulenta* (KK, NDI), Boiga (Toxicodryas) blandingii* (KK), Polemon christyi* (KK), Dendroaspis jamesoni kaimosae (KK), Dendroaspis polylepis (LVB, NDI, Elgon), Elapsoidea loveridgei multicincta (KK, NDI, Mau, LVB, Elgon, CHER), Naja melanoleuca (KK, LVB, NDI), Naja nigricollis (LVB, Mau), Pseudohaje goldi* (KK, Elgon), Atheris hsipida* (KK), Atheris squamigera* (KK, NDI, LVB), Bitis gabonica* (KK, NDI), Bitis nasicornis* (KK, NDI, LVB), Bitis arietans (Mau, NDI, Elgon), Bitis worthingtoni (Mau), Causus lichtensteini* (KK, NDI, LVB), Causus rhombeatus (NDI, Mau), Atractapsis irregularis (LVB, KK, Mau), Amblyodipsas unicolor (LVB), Causus resimus (KK, LVB, Mau, NDI) Testudines (3); Pelomedusa subrufa (KK, LVB), Kinixys belliana (KK, LVB, Elgon), Geochelone pardalis (LVB, Mara, Elgon)
Crocodiles (1) ; Crocodylus niloticus (LVB, Mara).

Appendix 2: Totals of wetland bird species recorded in the Lake Victoria wetlands-Kenyan sector in 14 sites counted between 1995-2007 except in 1996-7 and 2003, (Waterbird monitoring database, 1991-2007).

No	Common Name	Type	Scientific Name	Totals**
1	African Snipe-am	am	Gallinago nigripennis	13
2	Black-winged Stilt-am	am	Himantopus himantopus	2139
3	Cattle Egret-am	am	Bubulcus ibis	701
4	Collared Pratincole-am	am	Glareola pratincola	241
5	Grey-headed Kingfisher-am	am	Halcyon leucocephala	2
6	Knob-billed Duck-am	am	Sarkidiornis melanotos	55
7	Lesser Flamingo-am	am	Phoeniconaias minor	103
8	Pied Avocet-am	am	Recurvirostra avosetta	20
9	Red-knobbed Coot-am	am	Fulica cristata	13
10	Black-crowned Night Heron-am,pm	am, pm	Nycticorax nycticorax	2
11	Common Squacco Heron-am, pm	am, pm	Ardeola ralloides	64
12	Greater Flamingo-am, pm	am, pm	Phoenicopterus (r.) roseus	5
13	Black-tailed Godwit-PM	PM	Limosa limosa	28
14	Caspian Plover-PM	PM	Charadrius asiaticus	9
15	Common Greenshank-PM	PM	Tringa nebularia	472

16	Common Redshank-PM	PM	Tringa totanus	92
17	Common Sandpiper-PM	PM	Actitis hypoleucos	691
18	Common Snipe-PM	PM	Gallinago gallinago	80
19	Curlew Sandpiper-PM	PM	Calidris ferruginea	15
20	Eurasian Marsh Harrier-PM	PM	Circus aeruginosus	13
21	Garganey-PM	PM	Anas querquedula	7
22	Glossy Ibis-am, pm	pm	Plegadis falcinellus	93
23	Green Sandpiper-PM	PM	Tringa ochropus	3
24	Grey Heron-am, pm	pm	Ardea cinerea	59
25	Gull-billed Tern-PM	PM	Sterna nilotica	1604
26	Lesser Black-backed Gull-PM	PM	Larus fuscus	4
27	Little Stint-PM	PM	Calidris minuta	589
28	Marsh Sandpiper-PM	PM	Tringa stagnatilis	234
29	Northern Pintail-PM	PM	Anas acuta	79
30	Northern Shoveler-PM	PM	Anas clypeata	6
31	Osprey-PM	PM	Pandion haliaetus	1
32	Ringed Plover-PM	PM	Charadrius hiaticula	211
33	Ruff-PM	PM	Philomachus pugnax	1087
34	Spotted Redshank-PM	PM	Tringa erythropus	5
35	Whiskered Tern-pm	pm	Chlidonias hybridus	1446
36	White-winged Tern-PM	PM	Chlidonias leucopterus	1398
37	Wood Sandpiper-PM	PM	Tringa glareola	48
38	African Fish Eagle-R	R	Haliaeetus vocifer	77
39	African Jacana-R	R	Actophilornis africanus	788
40	African Marsh Harrier-R	R	Circus ranivorus	1
41	African Open-billed Stork-R	R	Anastomus lamelligerus	143
42	African Pygmy Goose--R	R	Nettapus auritus	12
43	African Skimmer-R	R	Rynchops flavirostris	200
44	African Spoonbill-R	R	Platalea alba	111
45	Black Crake-R	R	Amaurornis flavirostra	50
46	Black Heron-R	R	Egretta ardesiaca	1
47	Blacksmith Plover-R	R	Vanellus armatus	1
48	Common Moorhen-R	R	Gallinula chloropus	45
49	Crowned Plover-R	R	Vanellus coronatus	13
50	Egyptian Goose-R	R	Alopochen aegyptiacus	618
51	Fulvous Whistling Duck-R	R	Dendrocygna bicolor	160
52	Giant Kingfisher-R	R	Ceryle maxima	2
53	Goliath Heron-R	R	Ardea goliath	8
54	Great Cormorant-R	R	Phalacrocorax carbo	3594
55	Great Egret-R	R	Casmerodius alba	93
56	Great White Pelican-R	R	Pelecanus onocrotalus	59
57	Green-backed Heron-R	R	Butorides striatus	30
58	Grey Crowned Crane-R	R	Balearica regulorum	342
59	Grey-headed Gull-R	R	Larus cirrocephalus	178

60	Hadada Ibis-R	R	Bostrychia hagedash	285
61	Hamerkop-R	R	Scopus umbretta	752
62	Hottentot Teal-R	R	Anas hottentota	19
63	Kittlitz's Plover-R	R	Charadrius pecuarius	30
64	Little Egret-R	R	Egretta garzetta	6293
65	Little Grebe-R	R	Tachybaptus ruficollis	264
66	Long-tailed Cormorant-R	R	Phalacrocorax africanus	8481
67	Long-toed Plover-R	R	Vanellus crassirostris	124
68	Malachite Kingfisher-R	R	Alcedo cristata	44
69	Marabou Stork-R	R	Leptoptilos crumeniferus	14
70	Pied Kingfisher-R	R	Ceryle rudis	552
71	Pink-backed Pelican-R	R	Pelecanus rufescens	179
72	Purple Heron-R	R	Ardea purpurea	13
73	Purple Swamphen-R	R	Porphyrio porphyrio	10
74	Sacred Ibis-R	R	Threskiornis aethiopicus	1295
75	Spur-winged Goose-R	R	Plectopterus gambensis	1
76	Spur-winged Plover-R	R	Vanellus spinosus	348
77	Three-banded Plover-R	R	Charadrius tricollaris	36
78	Water Thick-knee-R	R	Burhinus vermiculatus	21
79	Western Reef Heron-R	R	Egretta gularis	2
80	White-faced Whistling Duck-R	R	Dendrocygna viduata	60
81	Yellow-billed Egret-R	R	Mesophoyx intermedia	77
82	Yellow-billed Stork-R	R	Mycteria ibis	207

Legend
AM-Afro-tropical migrant-migrating but confined in Africa
MM-Malagasy migrant-migrating within Africa and Madagascar
PM-Palaearctic migrant-migrant from Europe, Russia and Asia to Africa
R-Resident-species with local migration within Kenya and unlikely migrating outside
am, pm-migrants of that category occur alongside resident or non-migratory individuals (EANHS, 1996).

N/B ** the number is the totals of all individuals counted in the 14 different sites surveyed in 1995-2007

Appendix 3.. Threats to wetlands in Western Kenya and the relative percentages under threat classified by administrative boundaries

	Division	Protected by Individuals	Slightly Disturbed	Slightly Disturbed, Mitigated by Floods	Threatened	Threatened in Upper Reaches	Total Threatened	Total No. of Wetlands	% Threatened
	Kadibo							7	No data availab
	Kano							1	No data availab
	Kendu Bay							7	No data availab
	Kenyenya							6	No data availab
	Kosele							5	No data availab
	Lower Nyakach							16	No data availab
	Manga				11		11	11	100.00
	Marani				5		5	5	100.00
	Masaba							4	No data availab
	Miwani							2	No data availab
	Mosocho	1				1	2	4	50.00
	Nyando							10	No data availab
	Rangwe							5	No data availab
	Uranga							1	No data availab
	Winam							18	No data availab
al		1			16	1	18	102	17.65
Y	Aldai							2	No data availab
	Londiani							2	No data availab
Total								4	No data availab
	Amukura				7		7	7	100.00
	Bore ?							1	No data availab
	Budalangi		5	5			10	11	90.91
	Butula				9		9	9	100.00
	Chakol				4		4	4	100.00
	Sio Port							5	No data availab
	Un-specified				4		4	6	66.67
Total			5	5	24		34	43	79.07
		1	5	5	40	1	52	52	34.44

	District	Agriculture	Brick making	for agricultural	Clay harvest for jiko liners & other products	settlement/public	Fish farming	Harvesting of bait for Nile perch fishery	Large scale planting of Eucalyptus trees	Livestock overgrazing	Ocassional fires	macrophytes for raw	Proliferation of fishing villages within wetland	Reclamation for agriculture / horticulture	Sand mining	Stream channelization	Pollution	Mining of rocks & local quarrying	Introduction of alien species	NA Total from all sources of threat
RIFT VALLEY Total																				NA
WESTERN	[illegible]	2	1	5	1	1		2				5	1	7	1			1		27
	[illegible]		1			1			1	1		1		1		1		1		6 / 2
	[illegible]	1	1	1	2					1		1	2	2					2	7 / 3
WESTERN Total		2	2	5	3	1		2		2		7	1	9	1					35
Grand Total		7	7	7	4	4	1	2	5	3	1	1 2	1	1 4	1	4				73
	Kisumu																3			3
	Nyamira		2			1	1		2			3		1						10
	Nyando	2		1												1	3			7
	Rachuonyo	2															1		3	2
	Siaya	1								1										2
NYANZA Total		6	5	2	1	3	1		5	1	1	5	2	5		4	9		5	38
RIFT VALLEY	Kericho																			NA