PAPER PRESENTED

1. NILE BASIN INITIATIVE - Transboundary Environmental Action Project (NTEAP) - Overview

Our Shared Vision

In view of the scope and urgency of their shared problem and recognizing that cooperative development holds the greatest prospect of bringing mutual benefits to the region, the Nile riparian countries took a historic step towards cooperation in the establishment of the Nile Basin Initiative (NBI). Launched in February 1999, the NBI is a transitional mechanism that includes the ten riparian countries as equal members in a regional partnership to fight poverty and promote economic development through out the basin. The Initiative is guided by a shared vision

"to achieve sustainable socio-economic development through the equitable utilization of, and benefits from, the common Nile Basin water resources".

To translate the shared vision into action, the riparian countries developed the Strategic Action Program that has two complimentary programs:

1. the **Subsidiary Action Programs** to plan and implement investments and activities on the ground at the lowest appropriate level, and
2. the basin-wide **Shared Vision Program** to create an enabling environment for cooperative action through building trust and skill.

Shared Vision Program

The Shared vision program was established to create an environment for cooperative action through basin wide activities that help to build trust and skills. The SVP projects together, building a strong foundation for regional cooperation, build a basin-wide enabling environment; provide integrated approaches to water resources management, and coordination across sectors. There are seven SVP projects namely:

1. Applied training (ATP)
2. Confidence Building and Stakeholder Involvement (CBSI)
3. Efficient Water Use for Agricultural production (AGR)
4. Water Resources Planning and Management (WRPM)
5. Regional Power Trade (RPT)
6. Transboundary environment action (NTEA)
7. Socio-economic Development and Benefit Sharing (SDBS)

Transboundary Environmental Analysis

The varied and valuable environmental resources of the Nile Basin are subject to a series of threats with significant consequences for future development of the basin. The proximate and immediate causes of these threats have been studied extensively and are reasonably well understood, even though reliable data are scarce and some trans-boundary linkages require further elaboration. Many of these threats have direct impact on human health and welfare, while others undermine people's ability to secure their livelihoods. Collectively these threats represent a substantial barrier to long-term achievement of sustainable development in the Nile Basin Countries and so to their shared vision.

To identify and prioritize these threats, a Trans-boundary Environmental Analysis (TEA) was conducted jointly by the Nile Basin States, and several trans-boundary environmental threats were identified and categorized as follows.

Environmental Threats in the Nile Basin

Water quality degradation: The main threats to basin-wide water quality are insufficiently treated domestic, urban and industrial waste, non-point source pollution from pesticides and fertilizer residues, siltation and sedimentation, increased salinity and wetlands loss. Includes Pollution - point and non-point, Sanitation concerns – waterborne diseases and environmental health, eutrophication, water weed infestation and siltation

Land Degradation: Rain-fed agriculture and livestock grazing are the most widespread land uses in the Nile Basin and these activities are associated with serious and accelerating environmental degradation. Degradation in this sense means a decrease of the biological productivity expected of a given tract of land. The soil on degraded land is typically impoverished or eroded, there is less water available due to increased runoff or contamination, plant and animal productivity is lower, and wildlife less diverse. Includes Deforestation, Soil erosion, River bank and lake shore degradation, and mining impacts.

Loss of Biodiversity, Habitats and Wetlands: Wetlands in the Nile basin are threatened by drainage (for agriculture, industry and settlements), filling (for solid waste disposal, roads and settlements), dredging and stream canalization (for navigation and flood protection), hydrological alteration (for canals, roads, and other structures), ground water abstraction, siltation, and discharges of pesticides, herbicides and sewage. All of these reduce the value and productivity of wetlands. Includes Loss and destruction of valuable species, special ecosystems, and habitats, Wetland degradation

Disaster preparedness and Remediation: Flooding is a serious problem in the Nile Basin due to the high variability of both climate and river flows, compounded by the dependence of large numbers of people on the flood plains for their livelihood. Include Floods and Droughts, Refugees and displaced people, Uncertain impacts of Climate Change, Navigation risks, AIDS, and Mapping (oil Spills, boat discharges)

With the information provided by the TEA, the most important challenge for all parties concerned with sustainable development and conservation of the unique environment of the Nile Basin was to successfully make the critical transition from planning, in which goals and priorities are established, to the implementation stage, during which the objectives are incrementally reached. To do this, a prioritized agenda for environmental action in the Nile Basin emerged from the TEA process. The Agenda for environmental Action in the Nile Basin will be reflected in capacity building and investment programs of the Nile Basin Initiative in key Social and development Sectors.

An initial intervention to address a subset of the Agenda for Environmental Action was to focus on developing a framework for basin-wide environmental action linked to trans-boundary issues. This framework is operationalized through a project, the Nile Trans-boundary Environmental Action Project (NTEAP).

NTEAP Mandate

The NTEAP is one of the eight projects under the NBI Shared Vision Program. NTEAP will support the development of a basin-wide framework for actions to address high-priority trans-boundary environmental issues within the context of the Nile Basin Initiative's (NBI) Strategic Action Program (SAP). NTEAP will support the Nile Basin countries to develop sound approaches to dealing with trans-boundary environmental threats at the regional, national and local level. Focusing on trans-boundary issues provides the riparian countries with a major opportunity to make significant progress towards their economic and environmental goals in ways that have proved difficult to achieve independently.

NTEAP is a five year project (2003 – 2008), whose main objective is to provide a strategic environmental framework for the management of the trans-boundary waters and environmental challenges in the Nile River Basin. Specifically the project will:

1. provide a forum to discuss development paths for the Nile with a wide range of stakeholders,
2. improve understanding of the relationship between water resources development and the environment,
3. enhance basin-wide cooperation and environmental awareness, and
4. enhance environmental management capacities of the basin-wide institutions and the NBI.

Project Components

The NTEAP will achieve its objectives by supporting the implementation of priority actions in five main areas:

1. Institutional strengthening to facilitate regional cooperation: aims at enabling improved trans-boundary cooperation on environmental management among and between Nile Basin countries through improved communication, knowledge exchange and enhanced tools for environmental management. A large sub-component is devoted to supporting the development of a river basin model to improve the understanding of river basin hydrology, its response and trans-boundary implications of future development.

2. Community level land, forest and water conservation: will support pilot activities in geographic and thematic areas of trans-boundary significance. It will demonstrate the feasibility of local level approaches to land and water conservation, including mitigation actions for erosion, non-point source pollution, invasive water weeds, environmental awareness and NGO networking.

3. Environmental Education and Awareness: aims at increasing public awareness and understanding of the community and the common ecospace that the Nile creates. Activities especially target the future generation in the basin countries. Interventions will act on three levels: (1) the general public, (2) Primary and secondary schools, (3) University environmental education.

4. Wetlands and Biodiversity Conservation: will improve the understanding of wetlands function in sustainable development and improve management at selected trans-boundary wetlands sites.

5. Water Quality Monitoring: will initiate basin-wide dialogue on water quality and improve understanding of trans-boundary water quality issues, improve capacities for monitoring and management of water quality and initiate exchange and dissemination of information on key-parameters.

Expected outputs of the project are:

1. To increase regional cooperation in environmental and water management;
2. increase basin-wide community action and cooperation in land and water management;
3. increase the number of basin-wide networks of professionals;
4. increase the number of experts knowledgeable on the environment;

5. promote greater appreciation of river hydrology and more informed discussions of development paths, expand information, knowledge base and know-how on land and water resources;
6. create greater awareness of the linkages between macro/sectoral policies and the environment; and
7. create greater awareness and increased capacity on trans-boundary water quality threats.

Wetlands and Biodiversity Component

The Wetland and Biodiversity Conservation Component of the Nile Trans boundary Environmental Action Project (NTEAP) is aimed at enhancing the understanding of wetlands function in sustainable development and to demonstrate an improved management at selected Transboundary wetlands sites. The Component is building on nationally focused wetland conservation and management initiatives within the Nile basin, and is using the network of existing centres of knowledge and experience to provide a transboundary overlay of set perspectives to complement national wetlands conservation programs. The Component has four major outputs as follows:

1. Wetlands network established
2. Wetlands training and awareness programs developed according to needs
3. Ecological and economic studies on wetlands roles in sustainable development conducted
4. Pilot initiatives in support of capacity building and management completed

The component activities commenced during the 2nd Phase of the project at beginning of 2007. A wetlands and biodiversity working group has been established to enhance regional interaction and exchanges, and to help transfer knowledge, share experiences and build capacity for wetlands and biodiversity management in the region. The working group will links out to national experts and will prepare baselines on which to build future knowledge on wetlands and biodiversity in the region. The main tasks of the working group include:

1. To be a regional focus for the management and coordination of wetlands and biodiversity activities within the Nile Basin.
2. To assist in formulating national teams for wetlands and biodiversity within the basin.
3. Assist the establishment of the basin wide network of stakeholder representatives and experts in biodiversity conservation.
4. Link basin wide activities with government and NGO agencies responsible for managing wetlands and biodiversity.
5. Prioritise and plan joint activities, evaluate progress, compile and share lessons learned
6. To oversee the activities of wetlands and biodiversity at national level and sharing the national experiences at regional level.
7. Enhancement of key Nile conservation sites with global significance

The component, through the working group will develop wetland and biodiversity education, training and awareness programs emphasizing the transboundary aspects of the Nile Basin conservation, including habitat and species management and multiple uses of wetlands and integration of protected area management with local social and economic development as well as sound wetland conservation and management. The component will also conduct two in-depth ecological and economic studies with transboundary significance in order to strengthen management at priority wetland protected areas and build capacity through training and will prepare management plans at selected transboundary wetland sites and cross-border protected areas.

The component has three main sub components and the following activities:

1. Enhanced Regional Cooperation and Capabilities

A working group has been established and the challenge is to functionalize it so that intra and inter country linkages are formed within the basin. These will result in establishment of a basin-wide network of stakeholder representatives / experts in wetlands and biodiversity conservation and ensure that national issues are well articulated into the regional activities. The group will be guided on implementation of international recommended activities by the Ramsar and Biodiversity Conventions such as the criteria for selection of the sites for conservation, which will require a regional inventory for wetlands and biodiversity. The Sub component will also promote the development of the wetlands and biodiversity education, training and awareness materials, while building capacity by training officers who are directly involved in wetland and biodiversity management. An inventory (network) of officers who are benefiting from wetland training in the region will be developed.

2. Better Understanding and Broader Awareness of the Role of Wetlands in Supporting Sustainable Develop

The component will carry out in depth ecological and economic studies of the roles of wetlands and biodiversity in supporting sustainable development. The studies are aimed at providing a better understanding of wetlands and biodiversity to avail information for effective management. The studies will explore the ecological processes including water quality and hydrologic role of wetlands in flood control and the impact of wetland modifications and loss, on biodiversity. The studies will also assess the economic value and major threats together with the underlying social and economic functions, to provide information for effective management of its wetlands and transboundary protected areas. Two sites have been selected. Cyohoha sub basin in the NELSAP region and Lake Tana sub basin in the ENSAP region.

Cyohoha lies in the transboundary sub basin of River Kagera Basin located at the Rwanda Burundi border. There are several small lakes, some of which are seasonal and the others permanent. The sub basin has a unique ecosystem with evidence of rich biodiversity that have not been described. The wetlands of the sub basin are a major source of livelihoods to the riparian communities of the lake. The catchments are exclusively an agricultural area with potential threat of soil erosion and siltation which threatens the existence of the future of Cyohoha and its potential as the main freshwater body for surrounding communities and biodiversity conservation. The sub basin has received little attention, hence not much is scientifically known about its water quality, wetlands and biodiversity. Its hydrology is important to the existence of the wetlands and biodiversity in the tributaries Akanyaru, Nyabirongo, Akagera which feed in the main Kagera River.

The selection Lake Tana - Abby basin for in depth ecological, socio-economic and economic study, took into account preliminary observations, that there are already ongoing and proposed interventions in basin which would benefit from an in-depth study on water quality, wetlands and biodiversity. The study will endeavor to harmonize these efforts and fill information gaps not yet covered by other studies for the better management of the basin. The interaction with various ongoing studies and cooperation and consultation with the relevant existing actors will produce a harmonized product that will enhance the management of water quality, wetlands and biodiversity in the region. Consultations with other ongoing projects such as the Hydrology and Endowment and Growth Study by the Tana – Beles Integrated Water Resources Development project, and others proposed by the Ethiopian Government in the region will take place, including the several dams proposed on feeder rivers for lake regulation which may have an effect on river flows, water withdrawals, water quality and lake levels, as well as on wetlands and biodiversity.

3. More Effective Management of Wetlands and Transboundary Protected Areas

The activities of this component will commence with selection of sites for intervention, to prepare baseline assessment and preparation of management plans. The preparation of management plans will demonstrate collective responsibilities involved in managing complex transboundary wetlands and biodiversity sites. The component is at stage of developing ToR for the Sudd wetland which is the biggest transboundary wetland in the Nile Basin. Other sites proposed include, Dinder Aletash, Boro Akobo, Sio – Malaba and Cyohoha transboundary sites. The preparation of management plans is a process which will be strengthened by the formed working groups and network of experts.

It is also planned in this component that in conjunction with the ENSAP, an inventory of the wetlands and biodiversity sites of the Nile Basin will be made to guide informed decisions about their management. The component therefore expects that the major wetlands and biodiversity sites of the Nile basin will be assessed, analysed and mapped.

2. Opening Remarks: Dr. Henry Busulwa, Wetlands and Biodiversity Lead Specialist.

It gives me much pleasure to see nationals take responsibility over their own affairs. It would have been simpler for a consultant to move around to collect this information and give us the reports. In NTEAP we are conscience of capacity building.

We are looking for sustainability in whatever we are doing:

1. First this meeting would give us an opportunity to know each other. Who has done something in the Nile Kenya? It is important. This builds up on the work of LVEMP I.
2. Knowing each other would give us the basis to start sustainable long term 'specialized groups' of experts. We need them for continued performance and avoidance of reinventing the wheel. An expert should have done some work in that area and if he idenfiries himself, do a good job at it because you already know him.
3. Where are the limnologists, water quality, fisheries experts, invertebrates, herpetologists (may be there are none at the meeting) ornithologists, mammologists. We had a challenge in identifying these experts within the basin to carry out specific assignments. There is a lot of good will around and it is in order that we make a start, and define mechanisms that can be institutionalized to link up with the biodiversity focal desk for Kenya. It is from this desk that regional and international linkages can be appropriately known. In the case of Nile basin, we would wish to get the specialized groups linked regionally so that we can talk of the reptiles of the Nile, the birds of the Nile etc. In this way it will be easier to do programs together and get funds.

Going back to the baselines: this is our starting point.

- What do we know about the Nile Kenya at this point in time so that we build on it for the future?
- What are the gaps so that we re-direct our resources?
- What are the priorities?

From this baseline and the meeting it is possible to make recommendations so that the researchers go knowing which areas to focus on. It is our wish that at some point in time if we come again, we shall share experiences after filling the gaps we will have identified here. The papers you will present will be documented as the baseline for the wetlands and biodiversity of the Nile Kenya in which we think that information will be accessed and shared amongst resource managers, and users, but also it pays to know what exists on one side of the Nile which may be absent on the other.
Activities of the wetlands and biodiversity conservation

1. Regional working group has been established (members present). The working group is to assist
    - Institutionalization of wetland management in Kenya;
    - National wetlands policy development;
    - Wetlands strategy development (the baselines will help very much in development of the wetlands strategy;
    - NileWET regional management strategy for the Nile Wetlands.
2. Network of experts by wetlands and biodiversity specialized groups (this is the one we are forming now) will help in the enhancing the understanding of the wetlands role in sustainable development. And collecting and documenting the ecological and hydrological information about the wetlands.
3. Capacity building for transboundary wetland management through
    - Training and development of education and awareness programs to enhance training in the region.
4. Transboundary wetland management. In reference to Ramsar, there are no Ramsar sites in the Nile Kenya. These baselines shall particularly help us to make an official request to the Ramsar Secretariat to have some sites selected in the Nile Kenya gazette as Ramsar sites.

Sio-Malaba would form suitable transboundary Ramsar sites if Kenya and Uganda link up and submit one Ramsar Information Sheet (RIS) and Mara would form another one between Kenya-Tanzania if they submit a common RIS and agree on common transboundary management practices.

The component would wish to highlight other areas suitable for transboundary management in the Nile basin region just for your information

- Cyohoha sub basin between Burundi and Rwanda;
- Kagera subbasin-uganda, Rwanda, Burundi and Tanzania;
- Dinder Aletash – Sunda and Ethiopia;
- Tana sub basin – Ethiopia;
- Lake Nasser – Egypt and Sudan

I wish to thank you for coming and will report to the RPM NTEAP and ED Nile basin. I thank the LVBC for the continued support and collaboration, NPC for organizing, WG of Kenya.

Thank you all.

3. Paper 1 : classification and distribution of wetlands -Mr. Stanley Ambassa, LVEMP.

Introduction

The Lake Basin covers 38000 KM^2 and has 6 major rivers, Sio, Nzoia, Yala, Sondu-Miriu, and Kuja-migori and Mara. Topography of the basin comprises lowlands with scattered highlands rising to 1800 metres above sea level while the Climate is moderate to highland equatorial climate. The basin has high population growth rate of 3%.

LVEMP-Wetlands Management component collaborated with lead agencies in the basin to collect data for managing wetlands. Studies carried out include, rapid assessment of wetlands, buffering processes, mapping using remote sensing and GIS, traditional wetlands production and market surveys, and lesson learnt assessment.

Wetlands of Lake Victoria (K)

Definition: Ramsar defines wetlands as "areas of marsh, fen peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters".

Kenyan Definition

The Kenya Wetlands Working Group

"areas of land permanently, seasonally or occasionally waterlogged with fresh, saline, brackish or marine waters including both natural and man made areas that support characteristic biota".

Typically they are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support vegetation typically adapted to life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

Types

1. Permanent highland swamps at headwaters
2. Permanent low-lying wetlands-associated with lake shores
3. Freshwater marshes and palustrine/riverine wetlands found along key rivers
4. Seasonal swamps –found where rainfall is highly seasonal

Key plant species

1. *Cyperus sp,* the most dominant and include *papyrus, triandra, immensus* and *rotunders*
2. Phragmites spp-mainly found in the southern zones of the Kenyan portion of Lake Basin
3. Typha spp- widespread in the basin
4. Others include Vossiaspp, Potamogeton spp, Ceratophyllum demersum and Echinochloa spp
5. Invasive wetland weeds detected in the basin are *Eichonia crassipe* (water hyacinth), *Mimosa pigra* and *Penissetum spp* (Elephant grass)

Distribution

1. Major wetlands in the basin
2. Yala swamp-38000-52000ha
3. Nyando delta-14,000ha
4. Sondu miriu (Nyakachi bay)-3,500ha

Definition Wetland buffering

The net improvement in water quality between the inlet(s) and outlet(s) of a wetland.
The study focused most strongly on sediment and nutrient buffering, parameterising buffering of these in terms of net long-term reductions of loads flowing through the wetland.

Modeling Result

Detail monitoring was carried out on pilot sites at Kericho and Eldoret from May 2004-March 2005. The data was analysed using pond model which was customized to suit the local conditions. The pond model is implemented through Microsoft excel. The model was calibrated for the two sites and run for 11 years (1994-2004). (For results see presentation)

Results of Modeling Showed significant removal of suspended solids, phosphorus and nitrogen to occur in both wetlands. Scenario modelling showed that both wetlands are generally robust and would be expected to cope well with any environmental changes that may occur such as wetland area, inflow or pollutant loadings; however dramatic reduction in wetland area would be expected to seriously impair wetland buffering capacity. At basin wide level it was found that wetlands are responsible for retaining approximately 50% of the suspended solids and phosphorus leaving the catchment and approximately 30% of nitrogen leaving the catchment.

Gaps

1. Monitoring and management
2. Inadequate base maps
3. Lack of wetland policy
4. Poor networking among institution and researchers
5. Inadequate database
6. Inadequate Community awareness and participation
7. Capacity in manpower and equipments

Recommendations

1. Complete wetlands database and integrate with satellite imagery and GIS
2. Acquire high resolution Satellite imagery for mapping small wetlands in the Lake Victoria basin.
3. Continue with monitoring the pilot sites and basin wide wetlands
4. Immediate action should be taken to control invasive wetlands plant species
5. Strengthen community to develop wetland management plans.
6. Develop and implement wetlands strategies for the basin.
7. Improve insttutional and community capacity to manage wetlands.
8. Community education programs should be undertaken to ensure that stakeholders are fully aware of the ecological services that are provided by wetlands.

4. Paper 2: Socioeconomic and Cultural Diversity of Wetlands - Dr. Julius Manyala, Moi University

INTRODUCTION

General

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 2rd 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' and 34°53'E. It contains numerous islands and has a highly indented shoreline which Welcomme (1972) estimate as 3460 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.

Limnology

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 (Talling, 1966; 1969; Hecky & Fee, 1981; Hecky *et al*., 1981; Kilham & Kilham, 1990; Ochumba & Kibaara, 1989), climate shifts (Kendall, 1969; Livingstone, 1975) and introduced species (Barel *et al*., 1985; Hecky, 1984; Hughes, 1986; Ogutu-Ohwayo, 1990a; 1990b).

Limnological research in Lake Victoria was mainly done in the northern part near Jinja (Fish, 1957; Talling, 1957; 1966; 1969), and in the Mwanza Gulf (Akiyama *et al*., 1977); the brief visits of Worthington (1930); Melack (1976; 1979) and Kalff (1983) in the Nyanza Gulf and observation in Kenyan open Lake Victoria by Ochumba & Kibaara (1989). Apart from the works of Fish (1957); Newell (1960); Kitaka (1971) and Kite (1981), no detailed hydrographic description of the lake over a long period of time covering dry and rainy seasons is available. All the above collected information provide a base for the limnological characterization of the lake, but is short of indicating hydrological factors affecting biological productivity on a long term basis.

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. All these rivers form extensive wetlands at their mouth that support a variety of a source of community livelihoods through direct extractive activities of papyrus harvesting, medicinal plants, building material, grazing areas for livestock and water reservoirs for different uses among other economic activities.

Flora & 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 cited in the regional introduction 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*.

Fish taxonomy, fish ecology and fisheries

One of the major resources of Lake Victoria and its entire basin is the fisher. In this regard, the taxonomy, ecology and fishery of haplochromine trophic groups have been studied by Witte & van Oijen (1990) in Lake Victoria. Fish stock assessment has been carried out in the entire lake from time to time using bottom trawls (Kudhongania & Cordone, 1974; Marten *et al*., 1976; Benda, 1981; Muller & Benda, 1981, LVFO, 2000; 2005), catch assessment survey on artisanal fishery (Rabuor, 1988) and length-frequency analysis (Getabu, 1988; Asila & Ogari, 1988; Manyala, 1991). The stocks have been found to be changing drastically over time in species composition with marked decline in some endemic cichlids, especially the haplochromine species. This has been attributed to predation by Nile perch, over-fishing by destructive fishing methods (Whitehead, 1958; 1959; van Someren, 1959); papyrus encroachment and habitat degradation (Balirwa & Bugenyi, 1980; Ochumba, 1984) and probably pollution (Ochumba, 1984; Ochumba & Kibaara, 1989). After the disappearance of the haplochromine cichlids, Nile perch (*Lates niloticus* LINN.) has shifted its diet to the freshwater shrimp (*Caridina niloticus* LINN.), *L. niloticus* juveniles and the small pelagic cyprinid (*Rastrineobola argentea* PELLEGRIN 1904), the latter being perhaps the third most important prey and contributing some 10-20% in the diet (Ogari, 1984;1985; Ogari & Dadzie, 1988). Reasonable amount of studies are available on the impact of introduced *L. niloticus* and *Oreochromis niloticus* (LINN.) in Lake Victoria and Kyoga (Ogari, 1984; 1985; Ogari & Dadzie, 1988; Asila & Ogari, 1988, Ogutu-Ohwayo, 1990a;1990b; Ligtvoet & Witte, 1991).

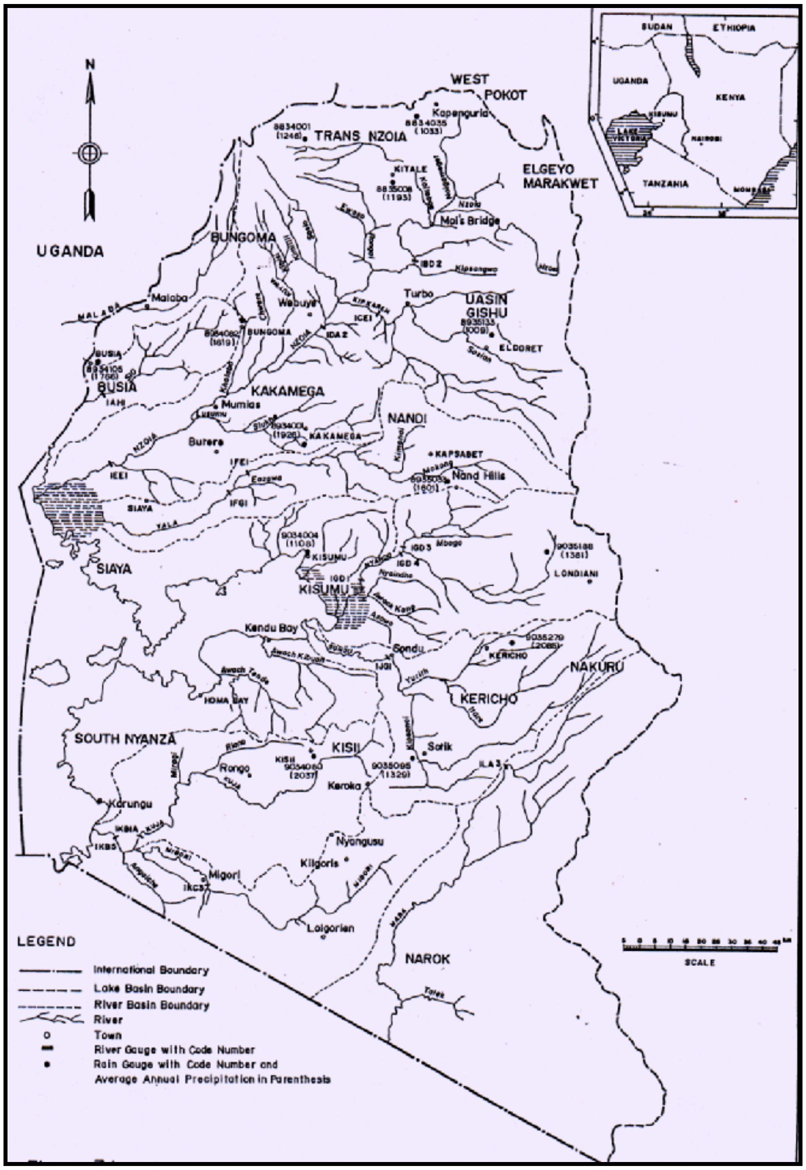

Figure 1: Lake Victoria Basin (Kenya): Main water resources indicating wetland areas. Source: Lake Basin Development Authority

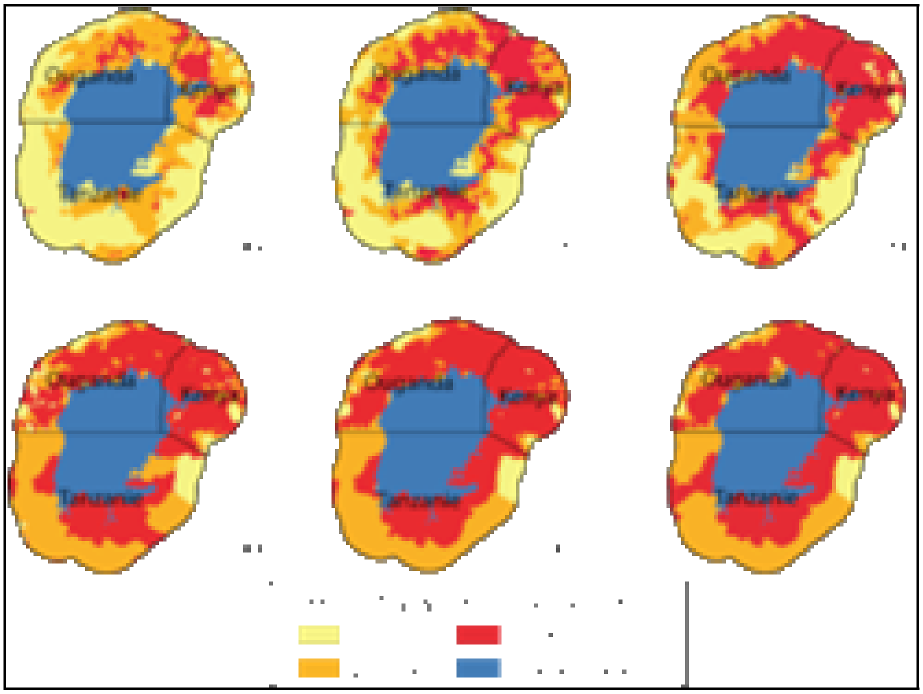

Figure 2: Density growth around Lake Victoria

Rivers and Associated Wetlands

These rivers rise in the highlands and flow into Lake Victoria, contributing a mean total volume of 7.29 billion m^3 water/yr. 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 4 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 asl, and the Ewaso Rongai, Koitobos and Kuywa Rivers have sources near the 3000 m contour. The Yala drains the central highlands west of the Rift Valley, as does the Nyando, which has sources near Mt. Tinderet (0°06'S/35°21'E) 2640 m asl. The Sondu 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 asl, and Moita (1°05'/34°44'E), 2037 m asl.

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 W-E and 15 km from N-S at the lakeshore. The swamp include 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 W-E and some 6 km from N-S. 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.

Other small wetlands, including seasonally flooded areas and permanent swamps, occur on the upper courses of these rivers and their tributaries. The most important of these are found at the foot of the dip 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 NW-SE and 1-5 km wide and used to extend to about 6000 ha. A small permanent swamp, c. 1000 ha is situated (0°52'N/35°13'E) north of the Little Nzoia River. A seasonal floodplain occurs on the Kimandi River, a tributary of the Yala River (0°12'-0°16'N/35°10'-35°16'E). This measures 12x6 km and covers 4800 ha.

Human Impact & Utilization

Both the Yala Swamp, and the Nyando and Sondu Swamps on the Kano Plains are being drained for agriculture. It is estimated that at least 14 000 ha of the Yala Swamp can be made productive, and by 1980, 380 ha had been converted for rice production. On the Kano Plains, 900 ha had been converted for rice and sugar cane. Recent data indicate that a total of 2,300 ha has so far been reclaimed in Yala Swamp in Siaya District.

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 phenomena, 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-chmicals and urban effluents.

Emerging scenarios include the wetland ecosystems claiming parts of available land and displacing community in the low-lying land areas eg in Budalangi (Busia District). This perpetual annual disaster cab be possibly attributed to poor land-use practices associated with population increase.

Wetland functions, values and uses

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

1. Building materials
2. Mats
3. Fisheries resources.
4. Pollutant sinks
5. Habitants for wildlife
6. Recreational areas (sports/hunting/bird-watching)
7. Grazing
8. 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 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 function and indirect (ecological) functions to the riparian communities. The wetlands are known to slows down flood waters i.e. storm abatement, they act as silt trap, water storage & 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 tomes, the use of wetland to extract clay for brick making has gained prominence in Western Kenya, but more conventional uses like mat and craft making are still widespread.

In some rare occasions, wetland resources serve for both aesthetic and direct use such as the circumcision ceremonies where clay soils smeared on the body.

With advent of severe encroachment in wetlands in Western Kenya, Many *Eucalyptus* trees have found their way into several of these wetland, 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.

Table 1: Threats to wetlands in Western Kenya and the relative percentages under threat classified by administrative boundaries

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

Table 2: Classification of potential threats to wetlands in Western Kenya showing the number of wetlands affected in each district

	District	Agriculture	Brick making	Burning in dry seasons for agricultural preparations	Clay harvest for jiko liners & other products	Encroachment for settlement/public utilities	Fish farming	Harvesting of bait for Nile perch fishery	Large scale planting of Eucalyptus trees	Livestock overgrazing	Ocassional fires	Overharvesting macrophytes for raw materials	Proliferation of fishing villages within wetland	Reclamation for agriculture / horticulture	Sand mining	Stream channelization	Pollution	Mining of rocks & local quarrying	Introduction of alien species	Total from all sources of threat
NYANZA	Central Kisii		2		1	1			2		1	1		3		2	2			15
	Gucha		1			1			1			1		1		1				6
	Homa Bay	1		1									2						2	3
	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
	Nandi																			NA
RIFT VALLEY Total																				NA
WESTERN	Busia	2	1	5	1	1		2				5	1	7	1			1		27
	Siaya									1								1		2
	Teso		1		2					1		1		2						7
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	12	1	14	1	4				73

NA: No data available on these areas

WHAT IS KNOWN IN THE AREAS SPECIFIED

For the purpose of this report, a wetland is defined according to Article 1 of the Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat as amended by the protocol of 3rd December, 1982. The convention defines a wetland as areas of marsh, fen, peatland or water, whether natural or articifial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.

All the wetlands could be grouped into broader categories as shown in Table 1. 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.

Wetlands in Western region are distributed along the main water flow systems and Lake Victoria itself. Table 2 shows the distribution of wetlands in the basin and covers the Yala, Kuja-Migori, Nyando, Lake Victoria shoreline and some inland water bodies. Data for the Upper Yala and Sondu-Miriu were not yet available for inclusion into this inventory. Some 151 distinct wetlands were identified throughout the basin but only 83 were broadly classified. Unfortunately, data on the estimate of area for almost all the wetlands is still not available.

Table 3: 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/fFoodplain
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

Table 4: The distribution of wetlands by administrative regions in Western Kenya

Province	District	Division	Wetland Name	Area	Altitude	Wetland Type
NYANZA	Central Kisii	Marani	Marani Swamp			Riverine
		Masaba	Ria Nyantudo Swamp			Riverine
		Mosocho	Etora Swamp	2.5		Riverine
	Gucha	Kenyenya	Nyabioto Swamp			Riverine
	Homa Bay	Rangwe	Oluch Mireji		3824	Riverine
	Kisii	Nyaribari Masaba	Suguta wetland			
		Keumbu	Kegati (Water Intake)		5809	Permanent Palustrine herbaceous swamp
		Manga	Kemera		5909	Permanent Riverine
		Masaba	Ramasha Wetland			Permanent Riverine
	Kisumu	Winam	Dunga			
		Winam	Okana Wetland			
	Migori	Awendo	Awendo Below Bridge		6690	
		Uriri	Bware – Oyani			Permanent Riverine
		Uriri	Gogo Dam			Palustrine
		Nyatike	Siko Wetland		3774	
		Nyatike	Wath Onger			
	Nyamira	Bosamaro west	Makairo wetland		6298	
		Nyamira	Kianginda (Enunda) Wetland		6328	Permanent Riverine
		Manga	Sironga Valley Bottom			Palustrine
		Rigoma	Bunyunyu		6055	Permanent Riverine/Palustrine
		Nyamira	Eronge			Permanent Palustrine herbaceous marsh
		Manga	Ekemera Valley Bottom – Ekerubo			Riverine
		Ekerengo,	Kiabonyoru.		6719	Permanent Riverine (edges of Perrenial stream)
		Nyamira	Sironga		6465	Permanent Palustrine Herbaceous swamp
	Nyando	Nyando	Nyando (Riat)			Lacustrine
		Nyando				Modified Wetland
		Lower Nyakach	Sondu Miriu Delta (Koguta)		3892	Lacustrine/Riverine
		Nyando	Singida		3830	Lacustrine/Riverine
		Miwani	Simbi	25	1200	Palustrine

Table 4: (Contd) The distribution of wetlands by administrative regions in Western Kenya

Province	District	Division	Wetland Name	Area	Altitude	Wetland Type
		Kadibo ?	Ombeyi		3857	

		Miwani	Oguodo	20	1200	Palustrine
		Lower Nyakach	Nyando Delta			
		Muhoroni	Muhoroni Treatment Works		4240	Man-made
		Lower Nyakach	Kusa Swamp		3750	Lacustrine
		Lower Nakach	Kobodho West/Kabila – Komwaga Beach		3821	Lacustrine/Floodplain
		Lower Nyakach	Kabodho West/Kabila			
			Chemelil Effluent Treatment Works			
		Kano	Awach Rae		1140	
		Nyando	Nyando Wetland complex			
	Rachuonyo	Kendu Bay	Sondu Miriu Delta (Osodo)		3839	Lacustrine/Riverine
		Kendu	Sondu-Miriu Delta(Osodo Bay)			
		Kosele	Kimira Wetland			
	Siaya	Uranga	Gangu-Nyalaji		3944	Lacustrine
			Yala (Kadenge)		3855	Lacustrine/Riverine
	Transmara	Pirrar	Angaseet (Chemamet) Wetland			Seasonal Riverine Floodplain
NYANZA/WESTERN	Siaya/Busia		Yala Swamp	23000	1155	Riverine/Lacustrine/Palustrine
RIFT VALLEY	Kericho	Londiani	Simboyon	1.25	7650	
		Londiani	Bartion Dam		7500	Man-made
		Londiani	Eastleigh Dam			Man-made
	Nandi	Aldai	Kamugorion			Permanent Riverine
		Aldai	Kibrong	200	1860	
WESTERN	Busia	Sio Port	Sio Delta			Lacustrine(floodplain)
		Budalangi	Nzoia Delta	120		Palustrine/floodplain
			Siteko-Maenje Wetland	15	3846	Palustrine/Riverine
			Sango/Sio confluence			
			Sigalame			
			Sio / Muramia			

Table 4: (Contd) The distribution of wetlands by administrative regions in Western Kenya

Province	District	Division	Wetland Name	Area	Altitude	Wetland Type
		Sio Port	Sio Delta			Lacustrine(floodplain)
		Sio Port	Sio Delta			Lacustrine(floodplain)
		Sio Port	Sio Delta			Lacustrine(floodplain)
		Sio Port	Sio Delta			Lacustrine(floodplain)

			Namulungu			
			Sio delta wetland			
			Mungakha			
			Sio Delta (Port Victoria)		3889	Floodplain
			Ludacho (Nawolo / Hainga)			
			Buduluku (Sango)			
		Budalangi	Bunyala (Musoma Beach)		3850	Riverine/Floodplain
		Butula	Esikoma			Riverine
		Butula	Murumba/ Bukhalire Swamp			Riverine
			Lerekwe			
			Nambale bridge			
			Lwanyange			
			Muluanda			
			Munana Dam			
			Munongo			
			Namalasire			
			Namanderema			
			Khayo Stream			
	Siaya	Boro ?	Uhembo/Mahur/Samba		3837	Palustrine/floodplain
	Teso	Amukura	Alteraite Swamp			Riverine
		Amukura	Kamolo Swamp	10		Palustrine/riverine

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 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 threats. Table 3 shows the wetlands distribution by source of threat and the percentage under threat in each disvision.

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. Table 4 shows specific threats to wetlands classified by district. 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.

WHAT ARE THE GAPS

1. incomplete Mapping of wetlands
2. NO Complete valuation
3. No Management plans
4. Lack of National Wetland Policy

WHAT NEEDS TO BE DONE

Management Plan

Wetlands in Kenya have for a long time been regarded as wasteland and on many occasions have been abused as dumping sites for urban and industrial wastes. They have also been destroyed in order to create land for other activities, e.g. land for agricultural activities. All these activities have threatened the wetland environment, biodiversity, wetland resources and reduced the overall value of wetlands.

In order to arrest this situation, there is an urgent need to define wetlands systems and identify their management strategies. All stakeholders (*Government Departments, Research Institutions, Non Governmental Organizations, Community Based Organizations and Village Committee*s) must be identified and their roles well defined, after which they must be involved in the management of wetlands at all levels. The problems associated with wetlands must be properly identified and understood before any possible solutions are found to address them. The existing national policies on wetlands ought to be reviewed so as to come up with policies that are in line with sustainable wetlands management.

National Environment Management Authority-NEMA (Wetlands Management)

There are several Government Departments, research institutions, non-governmental organizations, community-based organizations, village committees and cooperative societies that are involved in wetland management in one way or another. It is realized that there is duplication of roles and sometimes conflict of interest among these stakeholders. In order to bring order within the management of the wetland, the Government should establish a Wetlands Unit within NEMA or its associating agencies, which will be entrusted to do the following:

Define and establish a database for all wetlands systems and formulate their management approaches.

Set up effective management policies for wetlands, reinforce and review the existing and where wanting, enact by-laws to protect wetlands from; Industrial effluents; Municipal effluents; Commercial and service operations; (*Repair, servicing of motor vehicle and disposal of waste oils, Garbage collection and disposal of plastic wastes, disposal of industrial chemicals and expired drugs);* Mining activities; Damming and irrigation; Power generation; Agricultural activates (*Pesticides, fertilizers, Livestock grazing and watering*); Identify the resources within the wetland and come up with specific guidelines on sustainable utilization; Identify ways that the local communities can gain from wetlands and avoiding conflict in harvesting and access to wetland resources; Oversee all the management aspects of wetlands in the country; Coordinate the entire players with interests in the wetlands; Train personnel in wetland management and disseminate information on the importance of wetlands; Outline guidelines for conservation of fauna and flora within the wetlands.

Linkages

Existing legislation for water, lands, environment and fisheries Cap 378 could be very useful in identifying areas, which are relevant in supporting the sustainability of wetlands. National Environment Management Authority (NEMA) will rely on these areas to support its advocacy for the wetland management.

At the District levels, we have District Environment Committees, Divisional and Location Wetland Management Committees and at higher level, there is the Provincial Environment Committees. There are also other stakeholders such as World Conservation Union (IUCN), Lake Victoria Fisheries Organization (LVFO), Lake Victoria Environment Management Programme (LVEMP), which has Wetlands Management Component; is the body which initiated forming the location Wetland Management Committees. Some of the committees are active but some are inactive. The active ones even help in the regeneration of useful macrophytes like *Cyperus papyrus* .

Lake Basin Development Authority (LBDA) is a Government Parastatal, which has played a part by stocking some small water bodies with fish and aquaculture amongst other activities. In Yala Swamp it is actively involved in exploitation of the swamp resources and supports further reclamation of part of the swamp for rice scheme development by a foreign investor. Osienala, Ecovic and Uhai are other NGOs, which have sensitised communities on the need for wise use of resources in this region.

All in all; the main problem has been caused by population pressure on resource base like land, wetlands, forest, fisheries, water etc. Efforts should be made on reducing encroachment on wetlands, reducing deforestation, water pollution, air pollution, reducing poor waste management by applying pressure – state response reports in various environmental aspects. Areas, which are hot spots, should be gazetted for protection and sustainable use

5. Paper 3: Aquatic Invertebrates and Anthropods - Dr. Richard Bagine and Dr. Celicia Gichuki National Museums of Kenya.

INTRODUCTION

The Nile river Basin is shared by the ten countries namely; Burundi, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Uganda and Zaire. It drains an area estimated at 3,349,000 square Kilometer. The Nile River with a length of over 6,800 km is the longest river flowing from south to north and draining into the Mediterranean Sea.

The upper reaches of the Nile river Basin comprise of the Lake Victoria Basin which occupies an area of 251,000km2. The catchment area includes the Mau, Elgon and Cherangani with eight major rivers (Nzoia, Yala, Nyando, North Awach, South Awach, Sondu, Gucha- Migori and Mara) draining into the Lake.

About 75% of the Lake Victoria wetland area is significantly affected by human activities and degradation of the wetland inhabit is severe. It is also important to note that the basin together with its associated wetlands systems contains over 50% of the National fresh water resources. These wetlands provide important ecological services that bring benefits to humanity and associated life forms. The biodiversity of the Lake Victoria basin wetlands is affected by anthropogenic factors. Such threats minimize the ecological integrity of the ecosystem and social-economic benefits that is accrued from wetland resources. Conservation and management actions are essential for maintaining and saving wetlands biodiversity and its functions.

One of the largest groups of fauna that is associated with wetlands is the invertebrate group. Invertebrates are animals without back bone. They are the most numerous and diverse creatures on earth. About 97% of all animal species are invertebrates and life in terrestrial and aquatic environment. They play a critical role in the functioning of ecosystems such as nutrient cycling, food webs etc. Aquatic invertebrates live at least part of their life in fresh water ponds, Lakes, streams or rivers. For example, benthic invertebrates that 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, amoebas, 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) that comprise 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.

AQUATIC INVERTEBRATES IN LAKE VICTORIA BASIN WETLAND ECOSYSTEMS

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 example cooper (1996) carried out reviews and studies on the diversity, taxonomy and functional groups of aquatic invertebrate community with in the Lake Victoria basin. Similarly Sekirando et al (2004) studied the micro-benthic invertebrate (bottom-dwelling species) as indicators of water quality in Lake Victoria and its bays. The composition and abundance of benthic macro fauna was studied in details by Mothersill et al, in 1980 and Okedi in 1990. 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).

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 convenience investigates scientific curiosities. On the other hand very little is being carried out on aquatic inventory, conservation, biosystematics the role of invertebrates in wetland ecosystems. For example, Kenya Marine Fisheries Research Institute (KMFRI) co-ordinate and carry out research on fisheries biology, fish stock assessment as well as studies on invertebrates, wetland plant communities and to some extent water quality & 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 are 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 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 National Environment Secretarial Project Staff are involved in wetland inventorying in Lake Victoria basin and buffering capacity of wetlands studies in Sio, Nzoia, Yala, Nyando and Sondu-murui 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 L. Victoria have been studied by Masifwa, Twango and Denny. On the other hand, Mwebaza-Ndawula 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). The variation in composition of macro – benthic (bottom- dwelling) invertebrates as an indication of water quality status were studied by SBK Sekirando, et al (2004) in Lake Victoria and its bays.

Other investigations carried out on macro – invertebrate's fauna focused on their ecological role in the production dynamics in the lakes e.g. Corbet, 1991; Mavuti and Litterick, 1991; Mbahinzireki, 1992 and 1993; Lehman et al, 1994 and Mwebaza-Ndawula et al, 2001. Studies on macro – invertebrate as bio-indictors of water quality changes are cited by; Moog and Graf, 1994; Matagi, 1996; Sladecek, 1993; Persooner and DePauw, 1979 and Rosenberg & Resh, 1992. 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 in 2002. This provided valuable insights into the response on invertebrate communities to changing river water quality.

KNOWLEDGE GAPS & WHAT NEEDS TO BE CARRIED OUT

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 are there, their distribution and composition. There is need to carry out biodiversity surveys and inventories in L. Victoria basin wetlands. Modern technology such as satellite imagery and Geographical information system should be used to carry out a quantitative physical inventory of wetlands and their invertebrates in Lake Victoria Basin. The aquatic inverbrates 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. These invasive species 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.

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.
Ensure 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.

CONCLUSIONS

The knowledge base of aquatic invertebrates of the Nile basin within 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 needs 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 effort to understand the dynamic, magnitude and impacts of eutrophication, invasive species, climate change etc. on aquatic invertebrates.

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George Sikoyo – Focus on macro invertebrates of L Victoria ecosystem

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Shivoga, A. W – Focus on invertebrate communities in streams

Timothy Twango – Impacts of aquatic invertebrates, Uganda

Masifwa F W – Studies on alien water weed, Water hyacinth, Uganda

6. Paper 4: WETLAND MICRO-ORGANISMS WITHIN THE NILE BASIN IN KENYA: Dr. John Gichuki Kenya Marine and Fisheries Research Institute

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 ha, although this estimate is regarded as quite rough (Mathews and Fung, 1987). Saline and /or brackish wetlands comprise approximately 9 % 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. For instance Constanza *et al*. (1997) estimated that though wetlands cover 0.6-1.5% they produce $4,879 - $13,165 trillion in services per year which is 15-40% of the global total of $33,268 trillion.

Primary production is quite variable among the wetland types (Table 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 g C m^{-2} yr^{-1} and the total net primary production reaching more than 4000 g C m^{-2} yr^{-1} (Odum *et al.* 1982). Regarding the inland freshwater wetlands, *Cyperus papyrus* L. (Papyrus) Kenya had an above ground biomass yield exceeding 2060 g C m^{-2} yr^{-1} (Muthuri *et al.* 1989; Gichuki 2003)

Table 1. Characteristics of the world's wetlands. After Giblin and Weider (1992)

Wetland types	Area (10^6 ha)	Net primary production (g C m^{-2} yr^{-1})
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

1.2. Wetlands: several definitions

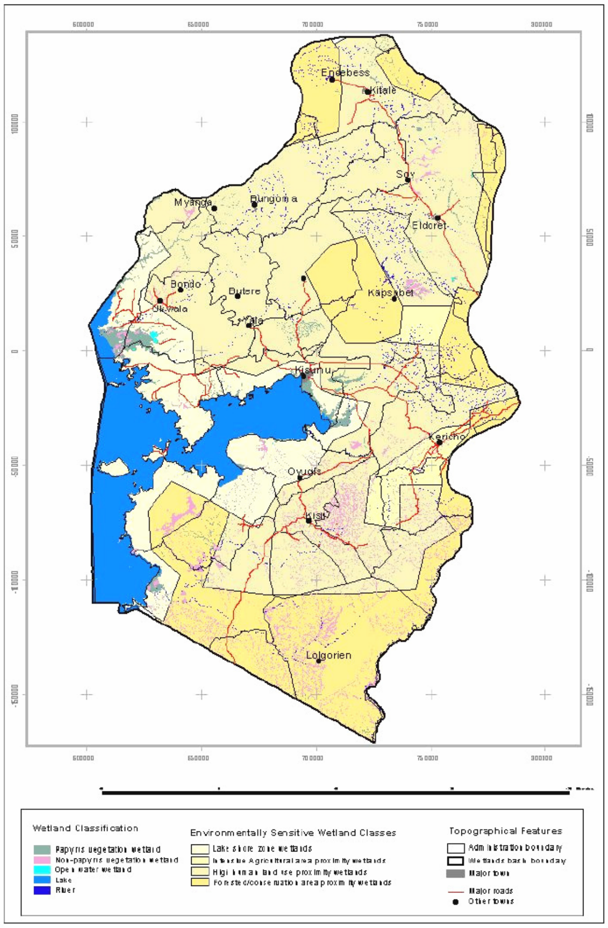
Wetlands are described as halfway world between terrestrial and aquatic ecosystems that exhibit some characteristics of each (Mitsch and Gosselink, 1993). They have seasonal and fluctuating conditions that make it difficult for one definition to adequately describe all wetland types. However, the recurrent 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 i.e. 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 aerenchymous 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 (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 defined as a type of wetland which is seasonally or permanently flooded / ponded, 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 leavy grass that can grow upto 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 *S. 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 (Gaudet, 1976). The plant forms the dominant emergent vegetation in most permanently flooded wetlands of tropical Africa (Hughes and Hughes, 1992; Thompson *et al*. 1979). 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 upto 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 t C ha^{-1}. 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.

1.3. Wetlands of the Nile Basin (EA)

The main wetlands within the Lake Victoria basin are; the Yala Swamp measuring 17 500 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 H/bay which is scheduled for drainage with the African Water facility having contributed about 2 million dollars for the activity. The Saiwa samp 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 1). Within the Ugandan part of the basin the main prominent swamps are Nabugabo and Kayuji as well as the Lake Kyoga which is surrounded by large papyrus swamps (Figure 2



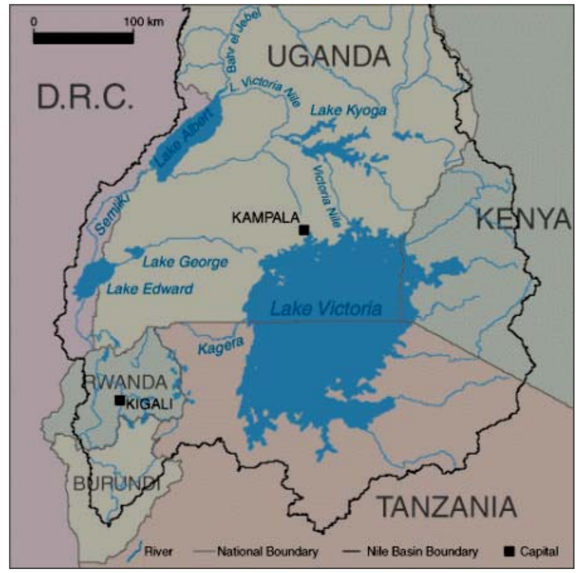


Figure 2. The East African Wetlands of the Nile basin

Figure 1: Wetland resources in the Kenyan portion of Lake Victoria catchment

1.4. The Sudd swamps

The Sudd is a swampy lowland located in the southern Sudan, in eastern central Africa (Figure 3). The region is about 320 km (about 200 mi) long and about 360 km (about 220 mi) wide with a total area of 380 km^2. It is fed by major tributaries of the north-flowing White Nile, including the Ba r al 'Arab. Just north of Bor, the White Nile overflows onto a broad clay plain. Because the gradient of the land is so low, the rivers' waters spread to form many swamps and lagoons. Papyrus and floating water plants, known in Arabic as *sudd,* grow densely in the region. The river is no longer navigable as half of its water evaporates in the slow-moving waterways. The Dinka and Nuer peoples live in the grassy plains between the watercourses. Since about the 10th century, these pastoral peoples have raised herds of cattle, sheep, and goats for their livelihoods. Previous attempts to construct a canal ie Jonglei canal, which would divert the flow of the Nile and make it navigable and also reduce the evaporation rates were hampered by the civil war in the southern Sudan. These attempts if ever they succeded would have resulted to the loss of the Sudd swamps.

1.5. Wetland functions

Wetland function refers to ecological, hydrological or other processes that contribute to the self-maintenance of the wetland and typically exert an influence (either positive or negative) on surrounding ecosystems. The main wetland functions are; Flood reduction and stream flow regulation; Groundwater recharge and discharge; Water purification; Erosion control by wetland vegetation; Biodiversity; Chemical cycling

1.6. Wetland values

Wetland values of wetlands are society's perception of the functioning of wetlands, and generally connote something worthy, desirable or useful to humans. The main values are; A valuable source of water ; Economically efficient wastewater treatment; Livestock grazing; Fibre for construction and handcraft production; Valuable fisheries; Hunting waterfowl and other wildlife; Valuable land for cultivation; Aesthetics

1.7. Microorganisms

Microorganisms are found everywhere in our watershed including the air, soil and water and these are one of the many living components of our ecosystem. Microorganisms are categorized into: Bacteria; Fungi; 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 accomplish 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.

1.7.1. Wetland Bacteria (Indicator species)

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.

The bacteria can grow singly or in associated group of cells including pairs, chains and colonies (Table 2). 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 and CO_2. 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.

Table 2. Classification of bacteria important in the wetlands (From Kadlec and Knight, 1996)

Group	Representative Genera	Comments
Phototrophic bacteria	*Rhodospirillum, Chlorobium*	Members of these genera are non symbiotic N fixers
Gliding bacteria	*Beggiatoa, Flexibacter, Thiothrix*	Filamentous bacteria present in activated sludge, *Beggiatoa* oxidizes the hydrogen sulphide
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 N fixer *Rhizobium* is a symbiotic N. 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 N. 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	*Nocardia, Frankia,*	Filamentous bacteria occurring aquatically and in soils.

Group	Representative Genera	Comments
organisms	*Streptomyces*	*Nocardia* spp is implicated in sludge bulking in sewage treatement Frankia is a symbiotic N. Fixer wit alder trees.

1.7.2. Bacteria mediated processes in the wetlands

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. Oxidize ammonia and nitrites for their energy needs and fix inorganic carbon dioxide (CO_2) to fulfill their carbon requirements) *Notrosomonas are* 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)

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 3). The main bacteria involved are; *Pseudomonas, Escherichia and Micrococus. The main* enzyme involved in this reduction is called *Nitrogen reductase* with the main cofactors being Iron and molybdenum

$$C_6H_{12}O_6 + 12NO_3^- \Rightarrow 12NO_2^- + 6CO_2 + 6H_2O$$

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

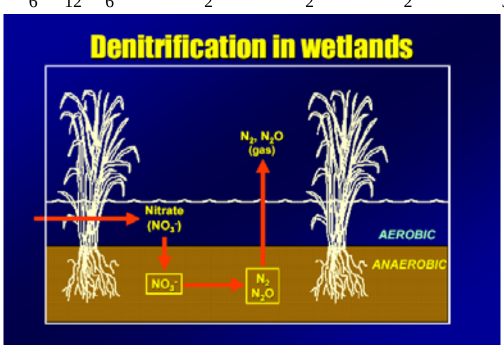


Figure 3. Denitrification processes in wetlands

Nitrogen fixing bacteria

N-fixing prokaryotes operate either anaerobically eg *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 Cyanobacteria or legumes (Rhizobium) where the algae secrete simple and complex organic and nitrogen compounds which the heterocysts feed on. 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 N fixed by biological processes is approx. 1.75 x108 metric tons yr^{-1}.

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).

Ferredoxin is generated by either photosynthesis, respiration or fermentation, depending on the type of organism

Nitrogenase is inhibited in the presence of oxygen. N-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.

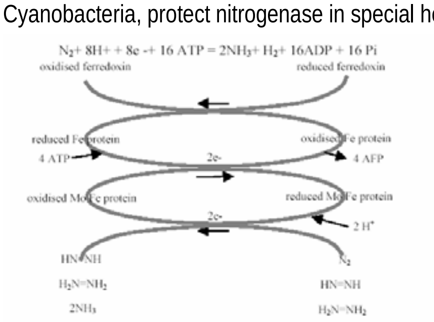


Figure 4. The formation of ammonium from nitrogen as mediated by nitrogen fixing bacteria

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 x 1 to 3µm in size and are non-spore forming. The bacterium best grows at 25 to 35^{o}C and pH range of 3 to 7. They have ability to gain energy from the oxidation of elemental sulfur and sulfur containing compounds ie 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, ie 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.

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

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)

1.7.3. 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)
Rhizophydium (parasitic types)
Saplolegnia
Allomycetes
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 hosts 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 P 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.

1.7.4. 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 posses 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.

1.8. Invasive species

The main invasive species in the wetlands include the parasites of Malaria, *Schistomiasis, Filariasis*, Yellow fever, Encephalitis, Tryposonomiasis and numerous lung and liver flukes. The parasites lay their eggs in still water in the wetlands where the wetlands create conducive breeding conditions.

The presence of these virulent strains has contributed significantly to push the case for wetland reclamation. These parasites can however be eradicated sustainably by for example using mosquito fish e.g. *Gambusia* spp.

1.9. Research carried out so far on the use of wetland micro-organisms and wetland environment

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 % BOD, COD, 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).

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

1.10 Wetlands under pressure

The main reasons why wetlands are under pressure is due to;

Magnitude of area and issues

Growing population

Intangible benefits

Narrow knowledge base

Lack of viable wise use options

1.11. Management options

Bring wetland conversion processes under control by making informed decisions where and where not to convert as well as to improve on the 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"

There is need to review sectoral policies that are conflicting eg the agricultural policy and environmental policy.

Finally there is need to gazette the wetland policy so the state can feel obligated to protect the wetlands.

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Introduction and background information of the Nile basin

The Nile Transboundary Environmental Action Project (NTEAP) is an international project implemented by nine countries (Sudan, Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, United Republic of Tanzania, and Uganda (with Eritrea having observer status) for purposes of conserving the catchments, riparian habitats and open waters which contribute water to

River Nile which straddles these countries. The main vision of NTEAP is to achieve sustainable and socio-economic development through the equitable utilization of, and sharing the benefits from, the common Nile Basin water resources. To address a combination of problems faced by wetlands at country levels NTEAP proposed investment in three strategic interventions: enhancing institutional capacity, wetland awareness and ecological and economic use of wetlands.

The component on wetland and biodiversity is an integral part of the NTEAP, because the Nile River and her associated open waters, riparian habitat and entire catchment can be described as a large wetland habitat which straddles many countries and benefits many people. Wetlands in Kenya are defined as areas that are permanently or occasionally waterlogged with fresh, saline, brackish or marine waters at a depth not exceeding six meters, including both natural and man-made areas that support characteristic biota (Kecha, *et al*., 2007). These definitions thus include swamps, marshes, bogs, swallow lakes, ox-bow lakes, river meanders and flood plains, as well as river banks, lake shores and seashores where wetland plants grow (Kecha, *et al*., 2007). Therefore, the wetland areas in the Nile catchment basin of Kenya could include the open waters in Lake Victoria on the Kenyan side, papyrus habitat around the lakes and the riparian vegetation along the permanent and semi-permanent rivers draining into the lake.

The Nile basin in Kenya comprises the Lake Victoria basin area, Kenyan sector or the Lake Victoria drainage basin. The basin therefore covers the sources of the main rivers which drain into the lake Victoria, which includes all land enclosed by the Kenya-Uganda border from Lake Victoria up to Mt. Elgon, to the Cherengani Hills, Mau Escarpment complex through the Masai Mara Game Reserve on the Tanzania border back to Lake Victoria. The total area of this entire region is 47,700 km^2 including wetlands and catchment areas of six major rivers that replenish it: Sio, Nzoia, Yala, Sondu, Nyando and Kuja (Kairu 2001). Other rivers that drain into the lake include Mogusi and Gucha. Other estimates put the area of Lake Victoria basin at 46,229 (NEMA, 2003).

The Kenyan sector of Lake Victoria basin has a large catchment area with an expansive wetland area comprising of open waters in rivers, riparian forests and papyrus vegetation on the fringes of Lake Victoria itself. There are more than six rivers which drain into Lake Victoria. The main sources of water for these rivers are more than thirteen different forests, (Kenya Tourist Board, 2000).

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 (Wetlands International, 2006). There are 878 waterbird species Worldwide grouped into 33 major families (Wetlands International, 2006). In Kenya there are more than 150 waterbird species (Zimmerman, *et al*., 1999).

Objectives of the Paper

The main goal of this paper is to provide information on wetlands and waterbirds in the Lake Victoria drainage basin area of Kenya. Specifically, the paper seeks to:

1. Document the areas waterbird research have been conducted
2. Document waterbird species recorded in the Lake Victoria wetlands and its catchment areas
3. Identify the gaps in research which require to be addressed
4. Recommend the way forward in the conservation of the wetland ecosystems and waterbird species.

The Nile basin/Lake Victoria basin in Kenya

The catchment basin of Lake Victoria and its wetlands, 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 (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 Escrapment 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 congregation of waterbird species at any given time (Fishpool and Evans, 2001; Bennun and Njoroge, 1999; Wetlands International, 2006). IBAs have also been shown to be Important Biodiversity Areas (IBAs). Figure 1 below shows the major catchment basin for the Nile basin while table 1 shows details of rivers originating from these sites and the conservation issues of catchment areas that provide water to Lake Victoria.

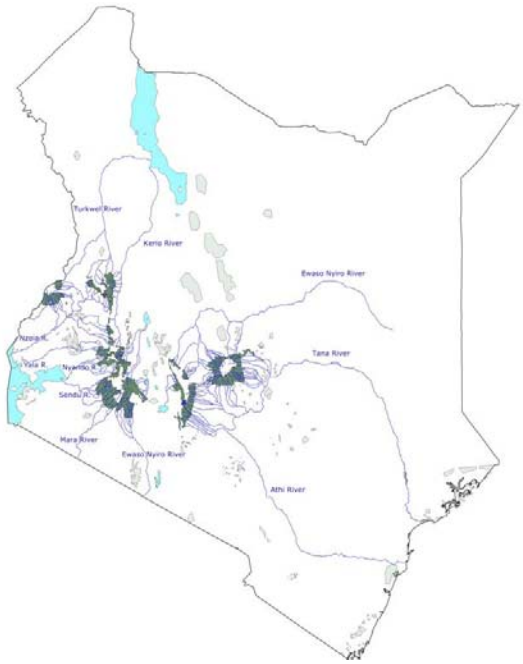

Fig: 1 Map of Kenya showing the major catchment region of the Nile basin. Map courtesy of UNEP/KWS

Table 1: Forest areas which form the catchment basin of Lake Victoria in Kenya, their conservation issues and specific rivers draining into the lake, (Kenya Tourist Board, 2000; Bennun and Njoroge, 1999).

Forest area	Status (bird conservation)	Rivers emanating to L. Victoria	Conservation issues that may threaten river catchment
Mau forest complex (Western, South-Western and Eastern Mau Forests)	IBA	Nyando, Sondu Sandul, Kipsonol (joins R. Kuja to form R. Gucha then to the lake, Kipsonol	Pressure on productive land-Okiek people, loss of forest (28% in 12yrs 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	Encroachment, de-gazettement 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, human pressure, illegal felling, forest fragmentation, 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 pop., several large excisions, 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 R. Kuya and joins R. 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

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 and that are habitat to very unique bird species. Some of these Papyrus fringes are under consistent pressure and has been cleared in some areas over the years, even though some remain in a few wetlands around it. These 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 2. 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 in to three categories depending on their water sources: riverine wetlands; inland delta wetlands; and freshwater swamps.

Wetland bird research surveys in Nile Basin in Kenya

Research on wetland attributes such as vegetation, water quality, fish and aquatic invertebrates etc 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, IBAs.

Table 2: Important Bird Area sites in the Nile basin, their status and bird conservation importance and threats (Bennun and Njoroge, 1999; Musila, *et al*., 2005; Ngw'eno *et al*., 2004; Munyekenye, *et al*., 2007)

IBA Site	Site Status & area	Key bird species	Bird status	Conservation issues	Notes and comments
Dunga Swamp	Unprotected, c. 500ha	Papyrus Yellow Warbler	Globally-threatened (Vulnerable)	Sewage solid waste from major town Excessive & unsustainable papyrus harvesting Water Hyacinth-related problem Require better formal protection (no conservation status at present	Most reliable for Papyrus Yellow Warbler All but one L. Victoria biome species found here
		Papyrus Gonolek	Globally-threatened (Near-threatened)		
Koguta Swamp	Unprotected, public land c. 1800ha	Papyrus Yellow Warbler	Globally-threatened (Vulnerable)	Water Hyacinth-related problem on fishing Excessive & unsustainable papyrus harvesting Overgrazing by cattle in dry spell Formal protection/community conservation programme (sustainable use of wetland)	Home of Papyrus Yellow Warbler Six L. Victoria biome species found here
		Papyrus Gonolek	Globally-threatened (Near-threatened)		
Kusa Swamp	Unprotected, public land c. 1000ha	Papyrus Gonolek	Globally-threatened (Near-threatened)	Uncontrolled cutting of Papyrus by locals Pollution & siltation from Nyando river Rice farming by local resident	Has substantial stand of Papyrus Papyrus Gonolek fairly abundant here Four L. Victoria biome species found here
Yala Swamp Complex	Unprotected, c. 8000ha	Papyrus Gonolek	Globally-threatened (Near-threatened)	Reclamation of the Swamp for agriculture for the dense population Irrigation water uptake Intensification of fertiliser & biocide input Unsustainable exploitation of Papyrus for the mat-making industry Extensive burning to open up area for agri	Important site for protecting the increasingly threatened suite of Papyrus birds Rehabilitation of feeder canal to L. Kanyaboli high priority-lack of regular inflow from Yala river changing its water chemistry & may interfere with its function as a fish refuge & nursery
		Papyrus Yellow Warbler	Globally-threatened (Vulnerable)		
		Great Egret	Regionally-threatened (Vulnerable)		
		Baillon's Crake	Regionally-threatened (Vulnerable)		
Sio Port Swamp	Unprotected, c. 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 utilisation 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 L. Victoria biome sp esp. 3 Papyrus endemics: Papyrus Gonolek, White-winged Warbler & Papyrus Canary

Much of information on wetland birds in the Kenyan sector of the Nile basin wetlands has only 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 3: Sites around Lake Victoria where waterfowl monitoring has been undertaken since 1995 (Waterbird Monitoring database, 1991-2007).

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

* indicate census done

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 a 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 institution, international and national and community-based organizations.

Waterbird species in wetland sites surveyed.

A total of 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 Annex 1.

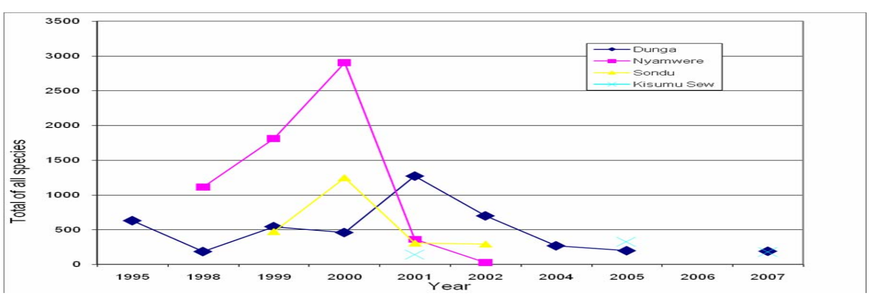

Fig. 2: Trends in total waterbirds in four sites of Lake Victoria wetlands, 1995-2007 (Waterbird Monitoring database, 1991-2007)

Waterbird censuses of the bird populations in the Lake Victoria wetlands have not been consistent. Therefore output of data analysis is limited. 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 4) and is the only site which has been counted relatively consistently among the 14 sites. Although a consistent set of data would reveal a better picture of waterbird populations of a site, Dunga swamp reflects fluctuating trends in waterbird numbers with a general decline from 2002 through 2007 (figure 2). This trend is reflected by the other sites, especially Sondu-Miriu and Nyamwere rice fields.

Table 4: Total numbers of waterbird individuals and species recorded in Dunga Swamp IBA since 1995.
Note: No counts were done at the site in 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

Conclusions

The Lake Victoria basin region, Kenyan sector, the catchment area for River Nile, is an extensive area which comprises open waters in the lake, the neighboring swamps and other smaller lakes, as well as the riparian ecosystems of rivers which drain into Lake Victoria. These wetlands are important for the conservation of waterbird species and avifauna in general. The classification of wetlands around Lake Victoria (Yala, Koguta, Kusa, Dunga swamp and Sio Port swamps) and the main water catchment areas of rivers draining into L. Victoria (Mt. Elgon, Mau Forest Complex, Kakamega Forest, South and North Nandi Forests and Cherangani hills) as IBAs is a recognition of the importance these sites play locally, regionally and internationally for the conservation of the waterbirds, avifauna and biodiversity in general. However, there has been limited waterbird ecological research conducted both in the proximity of Lake Victoria, along the permanent rivers and the associated riparian habitats save for only the annual waterbird monitoring scheme which has covered a total of 14 sites inconsistently since 1995. The acute shortage of information on rapid and detailed ecological surveys on wetland birds and their habitat in the entire catchment area is an indication that little is known about this group of species and their current status.

Recommendations

The conservations 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 River Nile basin region in Kenya is an extensive area cutting across many communities with different livelihood options and as such calls for concerted efforts to effectively manage this network of wetlands for the benefits of the local people, neighboring countries and biodiversity conservation. Wetlands are complex ecosystems which would need an array of strategies from different players working together to address all emerging challenges facing wetlands themselves and their catchment areas. Recommendations provided here are cross-cutting to all issues affecting wetland habitats and their biodiversity in general and specific to waterbird conservation interventions.

Wetland conservations interventions

Formulation of a national wetland policy in Kenya. Many wetland areas are not protected by law and have become prone to land grabbing after which they are reclaimed and converted to activities which are incompatible with biodiversity conservation initiatives. Loss of wetlands leads to loss of biodiversity, water, income and other ecosystems services. Buffer zone should be set a around each site, especially at areas historically comprising papyrus. This can only succeed if appropriate papyrus swamp conservation policy is enacted in Kenya

The wetland policy should also address the issue of community participation in wetlands management, conservation and utilization (deriving benefits) through sustainable exploitation of wetlands resources. It should therefore regulate and limit use to sustainable levels rather than prohibit human activities which are likely to elicit a counter-productive reaction among local communities to wetlands management. Participatory approaches to resource management have proved to be an effective strategy of encouraging resource-dependent local communities have the resource from which they derive livelihoods be available for posterity and therefore becoming custodians of the resource.

Strengthen Government, civil society and private institutions collaboration in addressing challenges faced by wetlands and their biodiversity. This will prevent duplication of activities and promote wise use of limited resources and therefore protect/Conserve the wetland areas.
Enforce the law on wise use, disposal of industrial effluent and sewage by ministries of environment, water and land, NEMA, Kenya Wildlife Service and Kenya Forest Service in wetland habitats such that human development and livelihood activities of the people do not negatively affect the wetland ecosystems.
Gazette the swamps around Lake Victoria (Yala, Kanyaboli, Koguta, Sio Port etc) and islands in the lake as legally protected areas. The legal protection will limit human activities which are currently encroaching into these sites and increasing their degradation.

Wetland birds conservation interventions

There is an urgent 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 because 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 derive more value from monitoring data.

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Annexes

Annex 1: 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*

8. Paper 6: Fish species diversity: a glance at the once speciose fish assemblage of the Nile basin in Kenya – Dr. W. Oweke Ojwang and Ojuok, J. E., Kenya Marine and Fisheries Research Institute; Kisumu Research Centre; P. O. Box 1881; Kisumu, Kenya. E-mail address: w_ojwang@yahoo.com

ABSTRACT
The fishes of Nile Basin in Kenya were four decades ago considered by many as one of the most speciose assemblages in the tropics. The basin is a mosaic of habitats comprising, Lake Victoria, satellite lakes (Lakes Kanyaboli, Sare and Nyamboyo), Rivers (Nzoia, Yala, Sondu/Miriu, Nyando and Kuja), Dams (Mauna, Mwer, Kalenyjuok, and Stella) and Swamps. 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, Schilbeidae, Mochokidae, Cichlidae, Mormyridae, Cyprinidae, Cyprinodontidae, Centropomidae, Bagridae, Cyprinidae, Mastacembalidae, Amphilidae, Anabantidae and Characidae in the Lake Victoria system. But in the recent past, some of the fish species, particularly the piscivorous guild of the haplochromines are feared to have gone 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*) 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 the fishery and fish species of the Nile Basin in Kenya respectively.

Key Words: Nile basin, Lake Victoria, rivers, fish species, sustainable exploitation

1.1 INTRODUCTION

The Nile basin in Kenya includes, the expansive Lake Victoria basin comprising of the main water body, effluent rivers, satellite lakes, swamps, small water bodies and the catchment area. The diverse aquascape support characteristic fauna and flora, some of which are endemic.

Lake Victoria itself spans about 412 km from latitude 0°30'N to 3°12'S and 355 km between longitude 31°37' and 34°53'E with a total area of 68,800 km^2. It contains numerous islands and has a highly indented shoreline which Welcomme (1972) estimate as 3460 km long. However, published shoreline measurements are notoriously variable, since they depend absolutely upon the scale of map used for their determination and how far each indentation is measured. Welcomme's estimate appears conservative, especially if island shores are included. Even though the lakes' surface area is shared between Kenya (6%), Tanzania (51%) and Uganda (43%), the catchment area is far much wider (184,000 km^2) distributed between Tanzania (44%), Kenya (22%), Uganda 16%), Burundi (7%) and Rwanda (11%).

1.1.1 Southwestern Rivers

These rivers rise in the highlands and flow into Lake Victoria, contributing a mean total volume of 7.29 billion m^3 water yr^{-1}. The most important ones are, from north to south, the Sio, which forms the border with Uganda, and the Nzoia, Yala, Nyando, Sondu and

Kuja/Migori Rivers. Between them are many minor streams. The Sio rises on the southern slopes of Mt. Elgon, while the Nzoia, a much larger river, with drainage of 12, 903 km^2, it rises high in the Cherangany Hills, but receives 4 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 asl, and the Ewaso Rongai, Koitobos and Kuywa Rivers have sources near the 3000 m contour. The Yala with a catchment area of approximately 3240 km^2 drains the central highlands west of the Rift Valley, as does the Nyando (3,356 km^2), which has sources near Mt. Tinderet (0°06'S/35°21'E) 2640 m asl. The Sondu originates from the western slopes of the Mau Escarpment and flows through a narrow gorge, penetrating the Nyakach Escarpment. It then meanders into the Odino falls before entering the flood plains of Nyakwere where it drains into Winam Gulf of Lake Victoria (Ochumba & Manyala, 1992), while the Kuja and Migori Rivers drain Mts. Kijaur (o°45'/34°58'E), 2166 m asl, and Moita (1°05'/34°44'E), 2037 m asl.

All these rivers tend to flood in concert, having catchments in high rainfall zones with a prolonged summer wet season from April to October. Since in places, the lacustrine plains are very flat, several of these rivers form extensive swamps on the lakeshore.

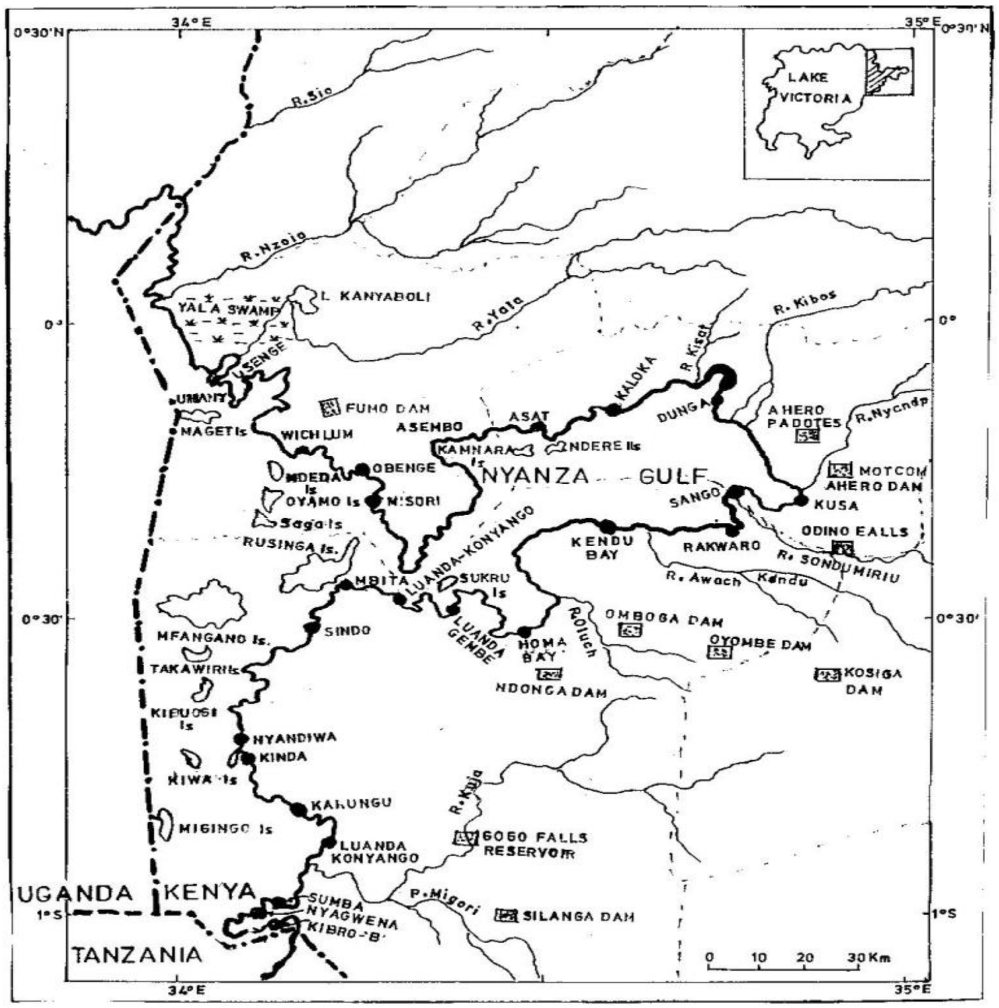
1.1.2 Swamps

The Yala Swamps (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. They also extend back up the Yala river in the south. In total they comprise 38,000 – 52,000 ha of wetland, including three major satellite lakes; the well known Kanyaboli (1500 ha), Namboyo and Sare (Abila *et al*. 2004).

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 W-E and some 6 km from N-S. Together the swamps on the Kano Plains occupy about 10 000 ha.

To the south of the Kuja 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 (0°28'S/34°31'E) near Homa Bay.

Other small wetlands, including seasonally flooded areas and permanent swamps, occur on the upper courses of these rivers and their tributaries. The most important of these are found at the foot of the dip 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 NW-SE and 1-5 km wide and used to extend to about 6000 ha.



Source: KMFRI Cartography Section

Fig.1. Lake Victoria and associted water bodies

1.1.3 Satellite lakes

Lake Sare

Lake Sare 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. The lake is about 5 km^2 and about 5 m deep at its centre. 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

Lake Namboyo is a very small but deep lake of between 10 - 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.

Lake Kanyaboli

Lake Kanyaboli (10.5 km^2) is one of the satellite lakes of Lake Victoria with a mean depth of 3 m. It has a catchment area of 175 km^2. It is 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.

Dams

Several dams are found in the Northern and Southern portion of L. Victoria basin with characteristic fish fauna. These include Stella, Olasi, Koketch (1° 05' 50 S 34° 26' 50 E) Uriri, Tinga Migowa, Oyombe (0° 26' 54 S 34° 39' 19 E) and Kosiga (0° 33' 38 S 34° 36' 54 E) to the South and Tinga Uranga, Ufinya, Kalenyjuok (0° 04' 21 N 34° 13' 02 E), Ugege (0° 01' 07 S 34° 16' 13 E), Mauna (0° 12' 30 N 34° 09' 23 E), Mwer (0° 07' 09 N 34° 10' 35 E) and Ulanda (0° 05' 57 N 34° 09' 53 E) to the North.

2.0 FISH SPECIES COMPOSITION AND DISTRIBUTION IN THE LAKE VICTORIA, BASIN

As aforementioned, Lake Victoria watershed is a mosaic of different habitats and realms: the pelagic and littoral compartments, satellite lakes, dams and rivers. 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 (see Seehausen, 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 (HEST, 1995). The web based site, the FISHBASE puts the number of native, endemic and introduced fish species of Lake Victoria basin at 223 (FISHABSE, 2005).

2.0.1 Introduced 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 (Lowe-McConnell, 1997). 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 & Dadzie, 1988).

2.0.2 Other exotic species

Other introduced species albeit unsuccessful include the reported presence of *Micropterus salmoides* (Largemouth Bass) and *Anquilla anquila* (European eel) in river Sondu/Miriu (Manyala and Ochumba, 1989) 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).

2.1 THE DIVERSE AQUASCAPE

2.1.1 Lake Victoria

Recent research surveys (Masai, Ojuok & Ojwang, 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 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.

2.1.1.1 Fisheries of Lake Victoria, Kenya

Although a number of indigenous species are still being recorded in the lake, the two introduced species (*Lates niloticus* and *O. 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 Fig.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, 1983; 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. 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.

Table I Fish species and percent occurrence in 23 sampled stations in Lake Victoria, Kenya (Masai, Ojuok & Ojwang, 2005)

Family	species	% 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
	Astatostilapia 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

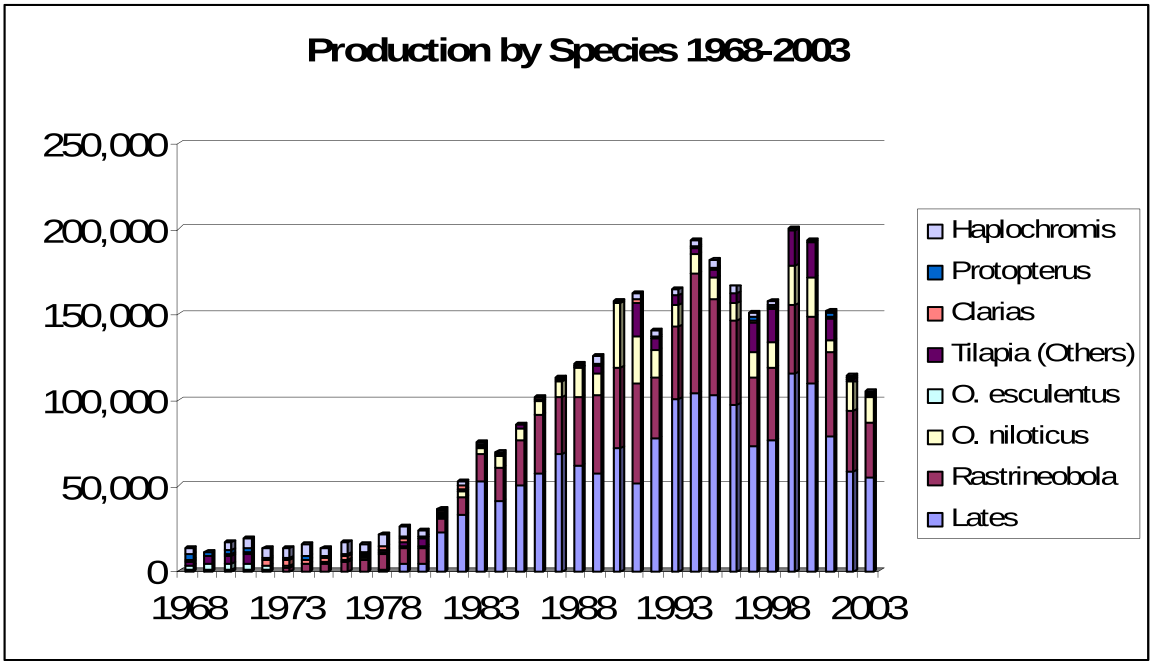


Fig.2. Annual catches (MT) from the Kenyan waters of Lake Victoria (1968-2003) (Source: KMFRI)

2.1.2 Satellite 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-SMB (Greenwood, 1974 & 1981; Mwanja *et al*. 2001 & 2004; Kaufman & Ochumba, 1993: Balirwa *et al*, 2003, Ojwang *et al*. unpublished data). 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 a continued campaigns for the protection of some 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's could act literally as boiler plates for speciation and thus speed up the multiplication of cichlids. SWB's are also important refugia for indigenous fish species other than the cichlids. Table 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 tilapiines are no longer found in Lake Victoria (Ojwang unpublished data). 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*. (unpublished data) 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 5-1).

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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 & de Winter, 1995)

2.1.3 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 of 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

Table 2: 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

Table 4. Checklist for fish species in rivers of Lake Victoria Basin, Kenya. (P- Present) Modified from Mugo and Tweedle, 1999.

Species name	R. Nzoia	R. Awach-Ahero	R. Nyando	R. S-Miriu	R. Awach-K Bay
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

Species name	R. Nzoia	R. Awach-Ahero	R. Nyando	R. S-Miriu	R. Awach-K Bay
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
Synodontis victoriae		p			p
Pseudocrenilabrus multicolor	p	p		p	
Chiloglanis cf. somereni	p				

3.0 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. 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.

4.0 Gaps in research and conservation activities

The major gaps in research include:

- 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

5.0 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 waterbodies to the livelihoods of the local communities.
- Several institutions have collected fisheries data within the basin and these information are scattered. 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 corruption witnessed in the sector.

6.0 Recommendations

In order to forecast the future of the lake, 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 dam, a sharp departure from current practice of treating the lake by and large as an isolated water body.

The restoration of the historic fish 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 wrong fishing methods and fishing along river mouths, are all strictly adhered to.

On the other hand, the reemergence patterns of fishes in the different aquatic compartments of the Lake Victoria basin are a sign of hope. The remarkable presence and numbers of native riverine fish species in the rivers of Lake Victoria is an important piece of the once speciose assemblage of fish species. The riverine assemblage contributed substantially to the bulk of the original indigenous fish species of Lake Victoria. The fact that there are only relict numbers of these fishes in the lake necessitates clear policies that safeguard the integrity of the rivers from harmful effluents from anthropogenic activities. Nonetheless the restoration of Lake Victoria fisheries is not a lost dream. It is clear that if persistent elements of the indigenous fish community were nurtured and human activity regulated under a unifying systems approach, a future diverse and ecologically efficient Lake Victoria could well be achieved.

The other options for proper management of Lake Victoria resources include creation of environmental protection awareness, designating key habitats as protected areas and revamping policing of the lake resources by law enforcers. The current lack of environmental awareness around the lake is deplorable. The inhabitants are not aware that they are partly to blame for the current status of the lake's environment. Educating the inhabitants of the lake region, especially the school going kids, is crucial. They must understand the ecological implications of having no sanitation facilities around the lake, of releasing untreated sewage into the lake, of targeting potamodromous fish species on their way to spawn upstream, and of using wrong fishing methods. There is strong likelihood that with this strategy the anthropogenic influences would be tremendously reduced, especially when you consider that those who would be the pioneers of the school program eventually become adults in the next 25 years and well versed on environmental protection concerns.

The use of reserves or protected areas to enhance persistence of endangered fish species in a perturbed environment has been implemented in different parts of the world with varied, but generally encouraging levels of success. Most of the relict fish populations in

Lake Victoria are currently found occupying isolated refugia (rocky outcrops and swampy areas), satellite lakes, and dam impoundments. Even though some of the SWB's are far too small and too phyico-chemically volatile to be viable conservation sites, there are a few such as Lake Kanyaboli, Lake Nyamboyo, Lake Sare and Mauna Dam that deserve to be secured and designated by law as protected areas.

Modeling techniques that involve the use of GIS (Global Information System) can be handy in assessing and maintaining key watershed processes in the Lake Victoria region. This will certainly enable protection of important habitats and species therein and also enhance evolutionary mechanisms required for the continued evolution of what remains of the Lake Victoria fish fauna. It is diminished, but still remarkable and extremely valuable, both to the people living about the lake, and to whatever future benefits might accrue from the continued basic study of these extraordinary fishes.

Last but not least, law enforcement is rather lax in Lake Victoria despite much discussion and good will toward doing something about this. Even though there are laws governing resource utilization, they are seldom implemented. Closed seasons when fishes are known to spawn are never observed. There are regulations on mesh sizes that could be used in sustainable utilization of the lake fishery but due to lack of motivation and corruption (law enforcers are inadequately remunerated), use wrong gears is as rampant in lake as ever. There are also laws regulating release of sewage and damping of industrial wastes into the lake but again these are never enforced. Better management of even the available (if limited) resources for policing the lake should be a priority if the invaluable lake resources are to be saved for the benefit of all.

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9. Paper 7: Wetland amphibians and reptiles in the Nile basin in Kenya - Patrick K. Malonza, National Museums of Kenya,

Abstract

The need to conserve species and their habitats is now more urgent than before as threats to biodiversity increases 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. Provided here are the known reptiles and amphibians mainly from anecdotal collection in within this region with special emphasis on wetlands. There are about 39amphibian and 100 reptile species with low endemism. The existing gaps (e.g. sampling in majority of the unexplored areas) that can aid in conservation of species and their ecosystem are identified. I recommend more 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 Kenyan Nile basin. Finally, all remaining indigenous forests and wetlands should be given highest conservation priority.

Introduction

Threats to biological resources are highest in the tropics where biodiversity is as well highest (Myers, 2003). The need to conserve biodiversity is now more urgent than ever as unsustainable use of natural resources escalates. Wetland and forest habitats are one of the most highly threatened habitats globally. They are especially important for their endemic and/or near endemic species. Wetlands provides a multitude of ecosystem goods and services, including water purification and regulation of flows, fisheries, habitat for plants, animals and micro-organisms, opportunities for recreation and tourism, etc. Their intrinsic hydrological processes buffer against such extremes as drought and flooding (Silvius et al., 2000). The Kenyan Nile basin has some of the most important wetland and forest ecosystems in the country. Majority of the wetlands include rivers, lakes, ponds, swamps and dams within and outside forest such as Saiwa and Yala swamps. Surprisingly most of these despite habouring high species diversity occur outside protected areas, a common global trend (see Rodrigues et al., 2006). The portion of Kenya constituting the Nile basin is small totaling to about 42,229 km^2 representing 1.5% of the total area of the basin. This is one of the wettest regions in the country and is characterized by high population density supporting close to 40% of the Kenya's population. The Nile basin ecosystem in Kenya include Mau complex forests, Cherangani Hills, Nandi Hills, Mt Elgon, and Kakamega forest which are catchments for rivers draining into Lake Victoria. Despite its diverse habitats and species diversity its amphibian and reptile fauna remain relatively poorly known. 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 & Howell (2006) on amphibians.

In this paper I present the approximate number of currently known amphibian and reptile species in the Nile basin in Kenya while highlighting recent species developments and threats. Provided also are the species conservation gaps for future work. I used published species lists, unpublished data from taxonomic experts as well as the National Museums of Kenya (NMK) herpetology collection database.

Species present

In the context of this paper I examine all the species from the areas that are within and form the catchments of major rivers that drain to Lake Victoria such as Nzoia, Yala, Sondu Miriu, Mara and Nyando. 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 – amphibians and -reptiles 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., 2005; Lötters et al., 2006; Lötters et al., 2007). From these studies in this forest, about 40 snake, 23 amphibian, 23 lizard and 1 terrapin species have been recoreded. 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 know 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, no ongoing species target research works in the region.

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 impotent 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 (see Schick et al., 2005).

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 amphaians (*Hyperolius lateralis*, *Leptopelis modestus* now *mackayi*) and retpiles (*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 as in the region. Some species like the frog *Arthroleptides dutoiti* known only from Mt. Elgon is known from the type material collected in the 1930s.

Conservation research gaps

Currently Kakamega forest is the most species rich area in the region. However, this is correlated to research efforts. Kakamega forest is the most intensively surveyed in all taxonomic groups. With more research in the other areas the biodiversity importance ranking of this region may become more evident as species lists of the other areas are yet to be established.

Recommendations

Studies are urgently needed to establish the conservation status of most of the rare and threatened species and their habitats. In particular studies should be done in the fragmented Mau Hills forest complex to determine the impact of the forest loss and fragmentation on its herpetofauna. Studies on the impact various human activities on these reptiles and amphibians need to be evaluated. More important biogeographical studies need to be conducted in the region to establish herpetofuanal similarities. Such information is important in the formulation of effective policy and management strategies.

In conclusion, future conservation efforts should encourage all local activities and initiatives that preserve indigenous wetlands and forests. In addition all existing indigenous forest fragments should be accorded highest conservation priority. Finally, I highly recommend conservation efforts that link or buffer small indigenous forest fragments and/or wetlands through reforestation programmes.

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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).

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10. Paper 8: Wetland mammals - Bernard R Agwanda, Mammal Section, National Museums of Kenya

The importance of wetlands to mammals can be traced to its role in the evolutionary adaptations of :
divergent evolution of Elephants, Dugong and Manatee:
Marsh and savannah Cane rats
Tragelaphin antelopes with sitatunga 'back in the swamp'
But it also plays *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) to 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 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 developments 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 Nile the basin, Kenya, this paper gives a brief on existence, habitat of and threats to some aquatic mammals within Nile Basin. Primary to this course, information gaps are highlighted to aid prioritizing future efforts.

Artiodactyla, even hooved mammals

a) Hippo, *Hippopotamus amphibius*

8 species lived in Africa about 1MYA, 4 of these lived in L. Turkana basin then, Now only 2 exist in Africa, & only1 of these two species in Kenya (*Hippopotamus amphibious*) Reasons for extinction of the other 6 species are not very clear, but climate change and increased human activities are thought to be 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,nYala, Nzoia, whole Victoria shore, and Mara have one of the major populations.

Food: Lawn mower of tussock & creeping grass

Ecological role: Limits fire incidences by removing grass layer:

Status: Quickly losing range and food

Threats: farming up to riverine, settlement; Killed for meat & due to conflict as a pest in farm

Population densities and responses Unknown; Foraging areas are alarmingly converted to farms of human homes and is the greatest threat. Water pollution (chemicals) suspected to affect under water suckling babies.

b) Sitatunga, *Tragelaphus spekei spekei*

This antelope is thought to have been exclude by its relatives from dryland and forced go to water where competition was not fierce. The populations in Kenya is of Nile Basin Sitatunga (T. s. spekei) distinct from Congo basin race

2 definite but small populations records are recognised: Saiwa & Kingwal-Eldoret. Yala and Nandi swamp population is contained in informal records but scientifically unrecorded.

Other informal records suggest recent historical ranges covered Homa Bay areas, South Nandi areas among other areas around L. basin and catchments of its rivers.

Habitat and Food

Heterogenous swampy bushes (bushes, herbs & grasses) preferred

Feeds on wetland grasses, herbs and shrubs (see fig below of Saiwa)

Most of its current habitats are half of what it requires and half of what is responsible its decline, human development (see fig below).

Homogenous/Monostands of specific vegetations are less preferred.

Farming encroachment destroys food resources and hunting for meat kills the population
Status: *T. s. spekei* is Endangered in Kenya
Reason Habitat loss and hunting
Population trends only known from Saiwa, others remains unknown.

Carnivora
Clawless otter, Spot-necked otter, Both are carnivore

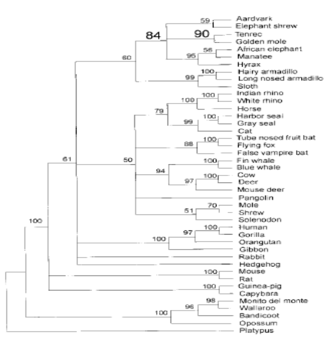
Clawless otter, *Aonyx capensis*
Has unwebbed feet, Relatively bigger than spot-necked
Habitat: prefer rivers and steams; Kingdon 1997 contends it's widespread in E.A , But documented from Yala, Nzoia,Mara (1975 expedition & NMK records). Recent studies indicate Saiwa swamp (Ogada, 2006)
Food: Fresh water crabs mainly, but also take frogs, molluscs, birds & s mammals
Ogada indicated sharp decline of otter populations due to several factors including increased turbidity of water from increased soil erosions. *? Sensitivity to water pollution especially through food chain not known yet*

Spot-necked otter, *Lutra maculocollis*
Recognition: 4-7kg ,half size of African clawless, Deep Golden in colour, throat offwhite with spots, Clawed
Habitat: Clear water in Lake Victoria rarely rivers
Food: Principally fish, but also frogs, aquatic inverts & molluscs
Threats: Soil erosion (turbidity)(Kingdon 1997), Fish nets and vandalism (Ogada 2006), Destruction of shoreline-breeding/feeding ground (Ogada & Agwanda)
Questions: Populations UNKNOWN; Status-UNKNOWN

Marsh mongoose, *Atilax paludinosus*
Recognition: - Dark brown with shaggy oily fur; Splayed hands
Habitat: Swamps on rivers or Lake shores (reedbeds, swamp grasses or bushes
Food: Crabs, Snails, Frogs,, Catfish, lungfish, Reptiles, Rats/mice, Birds, Larvae of invertebrates, They forge even in turbid water
Status: Stable from encounter rates, though has lost ground in many ranges

Giant Otter shrew, *Potamogale velox*
Recognition: - Smaller than otter, just a shrew, Bicolored-brown back & white underside, Improportionally large bladed tail, Broad snout in thick bristles, nostril with disc-shields, Swim like fish

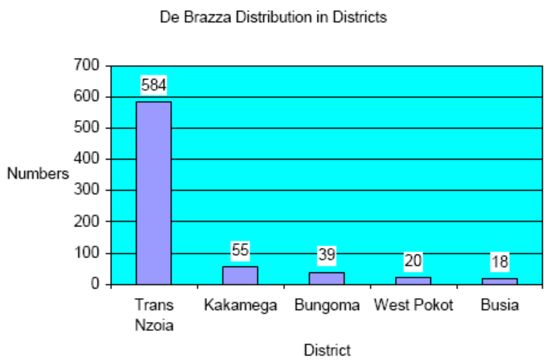
Taxonomically special in Kenya, relative of Madagascar Tenecs



Habitat
Only known from Yala & Nzoia River water in fast & slow waters but rest & breed in burrows in stable banks & beds
Food; aquatic invertebrates ; Small fish, frogs, mollusks; NOTHING ELSE KNOWN, other than records (Kingdon 1971)

Only Primate: De Braza monkey *Cercopithecus niglectus* Is not aquatic, but depends on riparian galleries, in Kisere, and many private forests in western Never leaves river course more than 200 m. Food: fruits & seeds, ocassional leaves
STATUS: very Rare and Endangered, due frequent conversion of its habitat to agriculture.
Seed disperser to riparian fig trees and others

See bar graph BELOW adopted from Mwenja (2006)



Location of Mammals in Nile Basin: Identified mammals in the basin are located as follows
80% in private farms
20% in protected area

90% in western Kenya
10% in R Valley

100% in riparian forests

Other Mammals Associated with Wetlands in Nile Basin are: - Marsh cane rat, *Thryonomys swinderianus;;* Shaggy swamp rat, *Dasymys incomptus;* Creek rat, *Pelomys isseli;* Lophuromys sp. Role of these species in the maintenance of Schistosome (Mkonji & Agwanda 2007)

BAT: Hammer headed bat (*Hypsignathus monstrosus*) inhabit riverine trees, palm

Briefs on Recommendations

Except for De Braza(Mwenja 2006, Bennan 1985) (& Otter (Ogada & Agwanda 2006) most records quoted are on 1970s observation. *Mara Hippos under study (E. Kanga)*Thus emphasis on need to re-affirm the records for most species; Mammal Inventories key to management; Threats & responses to activities and Populations monitoring.

Closing Remarks by the Provincial Director of Environment Western Province.

We in the districts and provinces are implementers and interpreters of the information generated by scientists and researchers.Many crucial environmental issues are at stake in the country. As we determine solutions for mitigating against each of them, we need to recognize synergies among them. It is also crucial to address the synergies of environment related issues among trade, economics, climate and biodiversity. We require deeper analyses of the technical and scientific aspects of these synergies. We also need to increase our knowledge about how these synergies work and how this knowledge could improve our policy development and implementation processes.
In performing our leadership role we are expected to facilitate the establishment of new partnerships by supporting

Our most immediate task is to agree on how to engage in further action for promoting the management, conservation and sustainable development of all types of wetlands in the nile basin. It would be desirable that the follow-up of this process continues to provide a forum for high-level policy development, co-ordination and policy implementation in an open, transparent and participatory manner.

Our most critical decisions should include clear indications of the means of implementation of sustainable wetlands management. We are entering a very competitive period, as we develop Kenya Vision 2030, we need to do so from an informed point of view. Kenya Vision 2030. As you know, Kenya Vision 2030 is the country's new development blue print covering the period 2008 to 2030. It aims at making Kenya a newly industrializing, middle income country providing high quality life for all its citizens. The vision is based on three pillars: the economic pillar, the social pillar and the political pillar. The Vision 2030 comes after the successful implementation of the Economic Recovery Strategy for Wealth and Employment Creation (ERS). The economic pillar aims at providing prosperity to all Kenyans through an economic development programme aimed at achieving an average Gross Domestic Product (GDP) growth rate of 10% per annum over the next 25 years. The social pillar seeks to build a just and cohesive society with social equity in a clean and secure environment. The political pillar aims at realizing a democratic political system founded on issue based politics that respects the rule of law, and protects the rights and freedoms of every individual in the Kenyan society.

The high economic growth rate and coupled with rapid urbanization projected in Vision 2030 will exert immense pressure on the country's natural resources and on the fragile environment. In order to sustain the economic growth while mitigating the impacts of rapid industrialization, it will be necessary for the country to adopt a sound policy on the environment. The full implementation of agreed actions is the main challenge now ahead of us.

Closing remarks by the Provincial Commissioner Western Province

Various stakeholders
Nile Basin Initiative Representative
Experts gathered here today
Distinguished guests
Ladies and Gentlemen

We are gathered here today in appreciation of the scope and urgency of our shared problem and in recognition that cooperative development holds the greatest prospect of bringing mutual benefits to the region.

The need for international water agreements and cooperation countinues because of the increasing possibility for water-induced conflict from issues of water scarcity and degradation, which poses as a continual threat to local, state, regional, and international stability.

The Nile riparian countries took a historic step towards such cooperation in the establishment of the Nile Bsin Initiative (NBI), which initiated a transitional mechanism that includes the ten riparian countries as equal members in a regional partnership to fight poverty and promote economic development through out the basin.

This has been achieved through two complimentary programs namely:

1. Subsidiary Action Programs;
2. Basin wide shared vision programs.

This project encompasses various mitigation strategies including water quality degradation; land degradation, loss of biodiversity, habitats and wetlands, disaster preparedness and remediation among others.

It is hoped the Agenda for environmental action in the Nile Basin will be reflected in capacity building and investment programs of the initiative in key social and development sectors.

Ladies and Gentlemen:
Wetlands conservation has been indentified as among the highest priorities by the NBI analysis and other research. Wetlands have long been important to the people in the Lake Victoria region for fishing and agriculture. However, under the changing circumstances of recent decades, resource use has changed, becoming more intensive and less discerning, to a degree that seriously threatens native biodiversity. The most grave and widespread threats are: Conversion of wetland habitat to intensive food production or drainage for upland crops and over-fishing.

This has led to emergence of invasive alien species, especially plants (hyacinth) and fish, altering the character and species composition of the wetlands, as well as contributing to extinctions of some endemic fish. This has also led to perennial flooding and serous threat to the livelihood of the local people.

In order to address this, the wetland and Biodiversity Conservation that is a component of the Nile Trans boundary Environmental Action Project (NTEAP) is aimed at enhancing the understanding of wetlands function in sustainable development and to demonstrate an improved management at selected Trans boundary wetlands sites.

Ladies and gentlemen
The valuable environmental resources available in this basin are under a constant threat, which cannot be avoided as they bear significant consequences for future development in the region. This ranges from impact on human health and welfare, which undermines people's ability to secure livelihoods to security and socio-economic issues. These threats have been compounded by a serious lack of adequate information and community participation, which would have enabled us to fully comprehend and address these threats.

As we are gathered here it is my hope as stakeholders we have strived to objectively highlight and discuss the pertinent issues related to our wetland and biodiversity in particular as they are very closely related to this region and specifically Western Province which has borne the brunt of yearly flooding of Budalangi affecting the livelihood of a large population.

The diverse effect of the problem has led to a reduction in the value and productivity of the wetland, destruction of valuable species, special ecosystems and habitats. This touches the core of the livelihood of the people in this region.

Ladies and Gentlemen:
I will not need to emphasize the importance of other mitigation measures including institutional strengthening to facilities regional cooperation, community land, forest and water conservation and environmental education and awareness that are key to ensure a wholesome approach in dealing with this emerging challenges. It is my hope that through NTEAP whose main objective has been to provide a strategic environmental framework for the management of the Trans- boundary water and environmental challenges in the river Nile basin we will be able to address this.

Ladies and Gentlemen:
It is my belief that opinion and experiences shared here will go a long way in helping us develop sound strategies which will assist in integration of protected area management with local social and economic development plans as well as sound wetland conservation and management. we need to appreciate that problems in the basin are intertwined and require a common approach.

It is my hope that we have exhaustively identified the link crucial in transforming our growing knowledge of the basin into tangible plans and priorities necessary to address the challenges leading to sustainable development and conservation of the unique environment.

Let us address these challenges using all available resources and stakeholders, which I believe this project is trying to do to ensure sustainability of the plan and preservation of the livelihood of our people.

Ladies and Gentlemen with your permission, I would like to end my remarks at this point and declare this workshop officially closed

A.K. MWASSERAH, EBS
PROVINCIAL COMMISSIONER
WESTERN PROVINCE

14th November, 2007